CORPS OF ENGINEERS, U. S. ARMY

FORECASTING TRAFFICABILITY OF SOILS

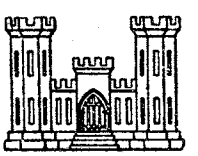
METEOROLOGICAL AND SOIL DATA

VICKSBURG, MISSISSIPPI

1948-1949

CONDUCTED FOR

OFFICE OF THE CHIEF OF ENGINEERS
RESEARCH AND DEVELOPMENT DIVISION



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REPORT NO. 1

WATERWAYS EXPERIMENT STATION

VICKSBURG, MISSISSIPPI

OCTOBER 1951

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FOREWORD

This report covers one phase of a comprehensive study to determine the relationship between the trafficability of soils and the mobility of military vehicles. The project was assigned to the Corps of Engineers by the Research and Development Division, General Staff, U. S. Army. The Waterways Experiment Station has been designated the development agency.

The investigation of soils trafficability as related to mobility of military vehicles is divided into three phases as follows: (1) soils classification and trafficability data or the development of methods and instruments for determination of trafficability by ground reconnaissance parties; (2) soils trafficability predictions or the development of methods to correlate soils trafficability with weather data sufficiently accurate to enable military planners to forecast the trafficability of soils in an area without physical tests; and (3) crossing areas of mud, sand, or unstable terrain or the development of portable roadways and construction of roadways from local and other materials for crossing very soft areas. The Waterways Experiment Station has been assigned investigation of the first two phases.

The majority of trafficability work accomplished to date has been under phase (1) and has included the development of testing instruments and the performance of laboratory and field tests to determine the mobility of military vehicles on different soils of varying strengths. Tests have been made under controlled conditions on five soil types, ranging from a coarse sand to a plastic clay, using self-propelled and towed vehicles.

Reports covering the work done under phase (1) are published under the general title "Trafficability of Soils," TM 3-240.

The work accomplished in phase (1) indicates that the trafficability of a soil is dependent directly on the strength of a soil together with its stickiness characteristics. An indicator test was developed in the form of a cone penetrometer which gives an index of the shearing resistance of the soil. An adaptation of Atterberg's stickiness test has been developed which determines whether a soil is in the sticky range.

It is considered that the cone index values obtained with the cone penetrometer can be correlated with the ability of the soil to provide the necessary bearing and traction capacity to support the traffic of given military vehicles. It is further considered that the stickiness test can be used to predict whether or not stickiness will occur.

Observations and tests have shown that both the cone index and the stickiness vary primarily with moisture content, therefore a correlation between these factors and climate appears in order if forecasts of soil trafficability are to be made. This report describes the first studies conducted under phase (2), forecasting of soil trafficability, which were based upon that premise.

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RESTRICTED

FORECASTING TRAFFICABILITY OF SOILS

METEOROLOGICAL AND SOIL DATA VICKSBURG, MISSISSIPPI, 1948-1949

PART I: INTRODUCTION

1. Previous studies have shown that the trafficability of a given soil will vary widely under different weather conditions since the strength and stickiness vary with moisture content of the soil. This report is concerned with a study of the effect of climatic conditions on the trafficability of soils.

2. The studies are a part of phase (2), forecasting soil trafficability, as outlined in the approved development plan "Trafficability of Soils as Related to Mobility of Military Vehicles." The work reported herein was authorized by the Office, Chief of Engineers, in the approval of the plans of tests for fiscal years 1948 and 1949.

Purpose and Scope

3. The purpose of this phase of the investigation of soil trafficability is the development of procedures for predicting the effect of climatic conditions on the trafficability of soils. Preliminary studies considered several approaches to the problem but did not develop a clear-cut program which appeared to assure success; therefore, the scope of the over-all program has not been determined. The purpose of the work reported herein was to obtain information for a few limited cases, from which a satisfactory program might be developed. This investigation included the measurement of rainfall, ambient temperature, soil moisture, density,

cone index, and stickiness at four natural locations in the immediate vicinity of Vicksburg, Mississippi, and the study of these data. Presented herein are the data collected and an analytical study for a one-year period.

Previous Investigations

4. The effect of meteorological changes on soil moisture is being investigated by various agencies interested in crop production and flood control. Though time and personnel limitations have not permitted a complete survey of available literature on soil moisture, review has indicated that correlation of soil strength with meteorological changes has not been previously undertaken.

5. Other parts of the over-all trafficability program which have been completed are reported under the general series title "Trafficability of Soils," Technical Memorandum No. 3-240. Listed in the order in which studies were conducted they are:

a.	Analysis of Existing Data	5th Supplement	May 1949
b.	Development of Testing Instruments	3rd Supplement	Oct 1948
c.	Laboratory Tests to Determine Effects of Moisture Content and Density Variations	1st Supplement	Mar 1948
d.	Pilot Tests -- Self-Propelled Vehicles		Nov 1947
e.	Trafficability Studies - Fort Churchill, Summer 1947	2nd Supplement	Aug 1948
f.	Tests on Self-Propelled Vehicles, Yuma, Arizona, 1947	4th Supplement	Apr 1949
g.	Tests on Self-Propelled Vehicles, Vicksburg, Mississippi 1947	6th Supplement	Sept 1949

Acknowledgments

6. The investigation reported herein was conducted by the Trafficability Section, Flexible Pavement Branch, Soils Division, Waterways Experiment Station. Engineers actively connected with the study were Messrs. W. J. Turnbull, W. K. Boyd, C. R. Foster, S. J. Knight, and R. G. Ahlvin.

Definitions

7. The 5th Supplement to TM 3-240 entitled "Analysis of Existing Data" contains a glossary of the terms used in the trafficability reports prepared by the Waterways Experiment Station. Those used in this report are defined below:

Trafficability. The capacity of a soil to withstand traffic of military vehicles.

Cone index. An index of the shearing resistance of soil obtained with the cone penetrometer. The value is a dimensionless number representing the resistance to penetration into the soil of a 30-degree cone of 1-in. base or projected area.

Cone penetrometer. A field instrument consisting of a 30-degree cone mounted on a shaft in such a way that it can be forced into the soil by hand. The capacity of the penetrometer currently used is 150.

Stickiness. The ability of a soil to adhere to vehicles under various conditions.

Plastic range. In certain applications it is more convenient to speak of the difference between the liquid and plastic limits as the

plastic range rather than plasticity index, as it is usually called. This is particularly true where moisture contents are designated with respect to the liquid and plastic limits. A moisture content halfway between the liquid and plastic limit is 50 per cent in the plastic range. The formula for determining the per cent in the plastic range is:

$$\frac{\text{Moisture content - plastic limit}}{\text{Liquid limit - plastic limit}} \times 100$$

Sticky range. The water content range in which stickiness occurs.

PART II: DESCRIPTION OF TESTS

Test Program

8. The test program consisted of the collection of meteorological and soil data at sites which were representative of some of the soil types near Vicksburg, Mississippi. At the outset of the program it was realized that there would be periods during the course of the investigation in which the test sites would be too hard and dry to constitute a problem in trafficability, and that the collection of soil data to full depths at such time would probably be time-consuming and expensive. Because it was considered that emphasis should be on poor trafficability conditions, the decision was made at the beginning of this investigation to use only data which could be obtained by the exclusive use of the cone penetrometer and the Hvorslev sampler as the basis of this study. Soil with a cone index of 150 was known to be capable of supporting traffic of any vehicle tested and soil which resisted sampling with the Hvorslev instrument had usually been found adequate for vehicular traffic. However, during the long periods when the Hvorslev sampler was found to be ineffective, occasional use was made of an auger and construction control sampler to secure samples. The year-round extremely high cone index conditions at the Rifle Range and Waterways Experiment Station flat sites were not foreseen. From an academic standpoint, increase in the capacity of the cone penetrometer was desired but from a practical trafficability standpoint it was not warranted. Thus, the data are not complete to full depths and vary appreciably in amount between sites.

Test Sites

9. For over a year four sites have been under investigation as a part of the soils trafficability prediction program. Plate 1 shows the locations of these sites. Two of the test sites, the Mound and Rifle Range sites, are located at the scenes of previous trafficability tests with vehicles. The other two, selected for comparison of flat and sloping ground, are located within the Experiment Station grounds.

WES flat site

10. This site is in a flat area on top of a loessial ridge. The soil is a lean clay, CL, according to the Department of the Army Uniform Soil Classification system. It has a liquid limit of 41 and a plasticity index of 18.

WES slope site

11. This site has a slope of about 15 to 20 per cent and is also located on top of the loessial hills. It was inadvertently selected at a place where construction operations had previously disturbed the surface layer. The material at this site is also a silt, ML. It has a liquid limit of 34 and a plasticity index of 9.

Rifle Range site

12. A third site is located about three miles southwest of the Experiment Station in a flat creek bottom area. The soil is alluvial outwash from the loess hills, and is also a silt, ML. The liquid limit is 37 and the plasticity index is 11.

13. The soils at the above three sites are very similar. Plate 2

gives grain size distribution curves, specific gravities, and Atterberg limits for the soils at these three sites.

Mound site

14. A fourth site, which is near Mound, Louisiana, is on river bottom land about 1-1/2 miles south of the present Mississippi River channel. The soil from the surface to about 18 in. has a liquid limit of 57 and a plasticity index of 27. The soil below about 28 in. has a liquid limit of 84 and a plasticity index of 52. A transition layer is between these two zones. The materials are designated fat clays, CH, under the Department of the Army classification system. Grain size distribution curves, specific gravities, and Atterberg limits for the soils at the Mound site are also shown on plate 2.

Equipment

Meteorological

15. The four test sites were served by three sets of meteorological equipment, a set at the Mound site, a set at the Rifle Range site, and a set at the Experiment Station serving the two sites there. Each set included a continuously recording rain gage and a thermograph. Standard rain gages and thermometers were located at the sites for checking purposes. A typical set of meteorological equipment is shown on plate 3.

Testing and sampling

16. Cone indexes were measured with the cone penetrometer and soil samples were taken with the Hvorslev trafficability sampler. In some cases

moisture samples were taken with an auger and density samples with a construction control sampler. (See TM 3-240, 3rd Supplement, for descriptions of the cone penetrometer and both samplers.) Stickiness was evaluated with a stainless steel spatula.

Test Procedures

Test plots

17. At each of the four test sites a 25-ft square plot was staked out and fenced. At the Rifle Range and Mound sites meteorological equipment was installed inside the fence. At the WES sites, a set of meteorological equipment already in existence was used. This equipment was located about midway between the two test plots. The 25-ft plots were divided into 5-ft squares. Rows in one direction were lettered A, B, C, D, and E, while rows at right angles were numbered 1, 2, 3, 4, and 5. This permitted the designation of individual squares, called data squares, as shown in the sketch below.

	A	B	C	D	E
1					E-1
2	A-2				
3					
4				D-4	
5		B-5			

Frequency of collection of data

18. Rainfall and temperature were recorded continuously and soil data were collected on periodic field trips. All sites were visited on

the same day in nearly every case. From the start of the program, August 1948, to May 1949, field trips were made about twice a week, usually following substantial rains, but never less frequently than once a week. From May to September 1949, field trips were made about once a week. Each time a site was visited, the recording weather instruments were compared with the corresponding standard instruments and adjustments made in the former where necessary. Instrument charts were changed weekly. On each visit to a test site, soil data were taken at four data squares within the test plot described in the preceding paragraph. Data squares were chosen at random, but care was taken to keep the squares on any day widely separated and to sample all squares before sampling any one the second time. For example, the data squares selected for testing on one day might be A2, E1, D4, and B5. In this manner a good coverage of the test plot was assured.

Soil data obtained

19. The data obtained from each of the data squares consisted of three sets of penetrometer readings and one set of soil samples. A set of penetrometer readings comprised cone index measurements at the surface and at depths of 3, 6, 12, 18, 24 and 30 in., and penetration to a maximum of 36 in. for the purpose of determining the depth at which 150 cone index occurred. When cone index readings of 150 (the limit of the instrument used) were encountered at some intermediate depth, that depth was recorded and an attempt made to continue penetration to ascertain whether the 150 cone index condition might be a thin layer with softer soil beneath. Such a condition occurred rather frequently at the Mound site. A set of soil

samples comprised specimens for water content at 0 to 1 in. and for both water content and density at 1 to 6 in., 6 to 12 in., 12 to 18 in., 18 to 24 in., and 24 to 30 in., unless sampling with the Hvorslev sampler became impractical to these depths. However, where soil conditions prohibited sampling with the Hvorslev instrument for a considerable period, soil augers and construction control samplers occasionally were employed to secure full sets of samples.

Test Data

20. The large quantity of data measured in the field has not been presented in detail. Instead, average data for the various depths are shown. The one-year period from 8 August 1948 to 8 August 1949 is covered. In the following paragraphs a brief account of these data is given.

Temperature and rainfall data

21. Temperature and rainfall data are presented in table 1. It will be noted that temperature data are not shown at the four test sites for the month of August, at some sites for parts of September and October, 1948, and occasionally for brief periods during the rest of the year. The temperature data for the first three months were not complete because thermographs were not then available. Omissions after the middle of October were due to faulty operation of the thermograph. Wherever temperature data at a site were lacking, the data for the Vicksburg Weather Station were assumed to hold. This assumption permitted plotting of the continuous curves shown at the top of plates 4-7. The temperature values shown in table 1 and plotted on plates 4-7 are mean temperatures, obtained

by averaging the maximum and minimum readings (taken from the thermograph trace) for the calendar day. Rainfall data are total amounts which fell during the calendar day as indicated on the recording gages. It will be noted that no rainfall data were available for the period 8 to 12 August 1948 at the WES sites. Nonavailability of data is indicated by dashes, and the absence of values indicates that no measurable amount of rain fell. Rainfall data are plotted in the form of a bar chart at the top of plates 4-7. The shaded bar is shown to the left of the date on which the rain occurred, i.e., rainfall on the 10th of the month is shown as a solid bar between the 9th and 10th.

Cone index data

22. The cone index data shown in tables 2-5 are average values of the twelve penetrometer readings made at each depth. A value of 150 appearing at the extreme right in a line of cone index values indicates a cone index of 150 or greater at the depth shown, persisting through lower depths. The depth at which a condition of cone index 150 or greater begins is shown in the column marked "Depth 150 CI." Cone index values for the surface and the average of the 6- to 12-in. readings (shown as 9 in.) are plotted against time on plates 4-7. For the Mound site (plate 7) 18-in. cone indexes also are shown.

Moisture content and density data

23. The sampling procedures employed frequently limited the number of samples taken at any given depth. As noted at the bottom of tables 2-5, the underlined values indicate averages computed for less than three samples. The depths indicated at the tops of the columns represent the

zones sampled. Average actual depths of sampling corresponding to 1-6, 6-12, 12-18, 18-24, 24-30 in. were 1-5, 7-11, 13-17, 19-23, 25-29 in., respectively. Where a moisture content value occurs without a corresponding density value, it may be assumed that the density value is lacking due to insufficient penetration by the Hvorslev sampler, and therefore that the water content shown is actually the figure for the upper portion of the specified depth. This possible discrepancy has not been considered in the application of moisture content data. The data shown in tables 2-5 are presented in graphic form on plates 4-7. Relatively thick lines are drawn between values obtained on consecutive field trips. Thinner lines connect values for greater time intervals.

PART III: DISCUSSION AND ANALYSIS OF TEST RESULTS

Effects of Seasonal Variations

Moisture

24. A study of plates 4-7 shows that at all four sites the moisture contents were high during the winter and early spring except where dry periods caused some reduction. During the remainder of the year, while more fluctuation was evident, the moisture contents tended to remain low except where temporarily increased by rain. This marked seasonal variation in soil moisture indicates a general correlation, shown in figures 2, 3, and 5 of plate 8, since the trends coincide with climatic conditions at this location. In addition to the general correlation, specific instances can be cited where rainfall produced definite increases in soil moisture. For example, on plates 4-7, rainfall on 1 and 18 November, 29 and 30 May, and 7 and 12 June produced increases in soil moisture at all four sites. Quantitative correlations were poor. For example, at the Mound site, 5.75 in. of rain on 1 November increased the 6- to 12-in. moisture content 8.8 per cent, while on 18 November 4.16 in. of rain increased the moisture content only 2.3 per cent. A further study of the data indicates that, except at the surface, the moisture content during the wet season reached an apparent maximum and further rainfall produced no appreciable change. During the dry season, the moisture content reached an apparent minimum beyond which the change was very slow, if there was any change at all.

Density

25. In general, no seasonal variation in the density was evident.

There appeared to be a slight trend toward high densities at the beginning of the wet and dry seasons followed by decreases, but evidence of the effect of any climatic conditions in producing these changes was not conclusive. There was some indication that variation in density was associated with changes in moisture along curves similar to laboratory moisture-density curves, but evidence was inconclusive. Since no specific trends in density were developed, average values have been used in subsequent computations involving the theoretical changes in moisture content produced by given amounts of rainfall.

Cone index

26. Cone index values showed a trend similar to that shown by moisture content. General trends are shown in plate 8 while plates 4-7 show that in the dry season, values remained high (usually well above 150) except for periods following exceptionally heavy rains, and during the wet season, cone index seemed to seek a natural minimum from which it would deviate only as a result of several consecutive dry days. In addition to the general correlation of cone index with climate, specific instances of the influence of rainfall can be cited. At the Mound site on 1 November, 2 to 5 January, 9 February, and 27 April, rainfall reduced the cone index considerably. On the other hand, appreciable amounts of rainfall on 25 and 28 November and 25 to 27 March failed to produce a corresponding decrease in the cone index.

Stickiness

27. There was a tendency at all sites for spatula stickiness readings of "some" to occur only at relatively high moisture contents.

Readings of "complete" stickiness occurred only in the Mound soil, and only at relatively high moisture contents. Overlapping of readings occurred at all sites. The following table shows the distribution of spatula readings with moisture content at the four test sites.

Frequency of Spatula Stickiness for Various Moisture Ranges

Per Cent Moisture	WES Slope Site			WES Flat Site			Rifle Range Site			Mound Site		
	N	S	C	N	S	C	N	S	C	N	S	C
15-20	123	0	0	87	0	0	188	0	0	76	0	0
20-25	191	1	0	249	0	0	253	14	0	209	2	0
25-30	396	9	0	270	0	0	99	5	0	164	9	0
30-35	144	34	0	70	37	0	30	9	0	357	65	9
35-40	27	8	0	21	19	0	12	3	0	135	94	1
40-45	3	1	0	3	3	0	5	1	0	27	32	3
45-50	6	0	0	1	0	0	2	0	0	5	13	0
50-55	0	0	0	0	0	0	0	0	0	1	1	1
55-60	0	0	0	0	0	0	0	0	0	0	2	0

N = "None" S = "Some" C = "Complete"

Correlation of Soil Characteristics with Climate

28. An attempt has been made to develop empirical relationships between the soil characteristics in the 6- to 12-in. layer and climate based on the consideration that the water in the voids in the layer was increased by rainfall and reduced by periods of dry weather. By trial and error it was found that moisture-climate relationships could be expressed by curves based on the following:

a. The moisture content was increased by an amount equal to 25 per cent of the water that fell as rain up to the field maximum beyond which no increase occurred.

b. The moisture content was decreased by drying 0.25 per cent per day during the wet season, and 0.50 per cent per day during the dry season down to the field minimum beyond which no decrease occurred.

c. The following values for maximum and minimum moisture contents and average density were used. These moisture content values were determined from plates 4-7, by subtracting one per cent from the actual maximum, and adding one per cent to the actual minimum.

Site	Moisture Content Max.	Moisture Content Min.	Density Lb/Cu Ft
WES Flat	25	12	97.5
WES Slope	30	9	86.5
Rifle Range	24	10	-
Mound	36	22	85.1

29. Figs. 1, 2, and 3 of plate 9 are plots of actual moisture contents measured throughout the year compared with values computed from the initial readings and the considerations stipulated above. Values for the moisture content are considered as basic data; however, the moisture content in itself has little significance unless it is identified with respect to the liquid and plastic limits. Accordingly, the moisture contents at the liquid and plastic limit are shown on the plots on plate 9. The moisture content and the density also can be used to compute the per cent saturation. Plate 10 shows a comparison of actual and computed values of per cent saturation.

30. A similar correlation can be made for cone index. The curve shown on fig. 4 of plate 9 was obtained by decreasing the cone index by 10 points for each inch of rainfall and by increasing it two points per day in the wet season and four points per day in the dry season. The correlation is shown only for the Mound site. The apparent minimum value was 95 and the apparent maximum was 165, but values are not plotted above 150.

Discussion

31. The correlation of actual values of moisture, per cent

saturation, stickiness, and cone index with computed values shows that a general relationship exists between climate and the soil characteristics which affect trafficability. The relationship appears to depend primarily on the change in moisture content between certain natural limits. It is apparent that the prediction of these changes requires information on both climate and soil characteristics which is not now known. This includes values for natural minimum and maximum moisture content and cone index, rate of change for rainfall, rate of change for both wet and dry seasons, and knowledge of when the change from wet to dry season occurs. The examples of correlation presented have not been greatly refined and it may be that additional refinement and further information will show that some or all of these factors follow systematic patterns.

Cone Index -- Moisture Content

32. Plate 11 shows plots of cone index versus moisture content for the Mound and Waterways Experiment Station slope sites. Cone index readings were limited in number for the other two sites, and no plots were made. It can be seen from plate 11 that a general relationship exists between cone index and moisture content. The spread of data is wide and no exact average curve can be drawn. The curves shown on the plots represent reasonable minimum limiting conditions.

Profiles

33. The two sites which were soft enough to yield a substantial amount of cone index data, the Mound site and the WES slope site, showed

rather unusual cone index trends with depth. This feature is discussed in the following paragraphs.

Mound site

34. Fig. 5 of plate 8 reveals that during the wet season the moisture content was high at the surface but was considerably lower at a depth of 6 in. Below 6 in. the moisture content showed a consistent trend to increase slightly with depth during the wet season. The cone index (fig. 4 of plate 8) shows the effect of the high moisture content at the surface and the lower moisture content at 6 in., but it will be noted that the cone index below 18 in. shows an increase which is not indicated by the moisture content. In seeking the cause of such an increase, soil samples were secured at three locations at depths of 0 to 2 in., 3 to 6 in., 17 to 20 in., 22 to 26 in., and 28 to 31 in. Atterberg limits for these samples are as follows:

Depth In.	Liquid Limit			Plasticity Index		
	1	2	3	1	2	3
0-2	56.9	58.5	58.0	25.7	24.6	27.2
3-6	57.9	59.8	60.3	26.6	24.1	29.8
17-20	50.0	53.2	55.4	23.2	24.3	28.9
22-26	64.0	65.1	58.0	37.7	39.6	31.9
28-31	58.2	80.9	86.7	30.6	49.0	54.5

35. It will be noted that a reasonable uniformity of these limits occurs from 0 to 20 in. By averaging the nine samples in this layer, a liquid limit of 56 and a plasticity index of 26 is obtained. At locations 2 and 3, a pronounced change in Atterberg limits occurs in the soil after progressing downward to about 28 in. Other projects conducted by the Waterways Experiment Station at the Mound site tend to verify this. Average values for liquid limit and plasticity index for the soil below 28 in.

are 84 and 52, respectively. The soil between 20 and 28 in. is considered to be transitional between the upper and lower levels of soils described.

36. As shown in a previous report (Trafficability of Soils, 1st Supplement, "Laboratory Tests to Determine Effects of Moisture Content and Density Variations"), cone index varies with plasticity index and with per cent of moisture content beyond the plastic limit. For a given per cent in the plastic range, the cone index is higher for higher plasticity indexes. Plastic limits and moisture contents are about the same for the two soil zones at the Mound site, but the lower soil has a much higher plasticity index. The higher plasticity index and the corresponding lower per cent in the plastic range explain the higher cone indexes below 18 in.

WES slope site

37. Some months after selection of the WES slope site it was found that the area had been filled to a depth of about 6 to 12 in. by construction operations carried out several years before. This accounts for the unique profile indicated in fig. 1 of plate 8. The top 12 in. evidences considerable seasonal variation, while below this, cone index values of 150 are encountered throughout the year. The effect of this disturbance is indicated in various other comparisons. Also, the wide range in natural soil moisture limits and densities relative to other sites indicates the existence of disturbed soil overlying the natural soil at the slope site.

Soil Moisture on Slope vs Flat Site

38. Plate 12 is a plot of moisture content at the WES slope site versus moisture content at the WES flat site. Each point represents

values for both sites at the same depth on the same date. Data for the whole year at depths to 18 in. have been used. An average curve through the points approaches a 45-degree line drawn through the origin, indicating very close agreement in average moisture contents at the two sites. Since it would be reasoned that equal amounts of rainfall would result in a smaller amount of moisture in the slope site, it is possible that the disturbance mentioned in paragraph 37 could have influenced the results.

Trafficability of Soils at Test Sites

39. A table of average cone index requirements for the vehicles tested in previous investigations is presented below. The cone index values given are for Rifle Range clayey silt, taken from TM 3-240, 6th Supplement. The tow load shown is per cent of maximum drawbar pull with wheels or tracks spinning. The latter value is usually about 90 per cent of the gross weight of the vehicle.

Vehicle	Indicated Cone Index Requirements
Nontowing vehicles	
LVT4 landing vehicle	50
4-ton truck	55
M26 tank	55
M24 tank	60
2-1/2-ton truck	60
6-ton truck	60
T92 mobile howitzer	65
Tractors towing 10% load	
M4A1 hi-speed	40
M4 hi-speed	50
D7 engineer	55
D4 engineer	55
M6 hi-speed	60
M5 hi-speed	65

Vehicle	Indicated Cone Index Requirements
Tractors towing 50% load	
M4A1 hi-speed	70
M4 hi-speed	70
D7 engineer	70
D4 engineer	70
M6 hi-speed	75
M5 hi-speed	90

Rifle Range and WES flat sites

40. The cone indexes in the 6- to 12-in. layer at the Rifle Range and WES flat site invariably remained above 150 throughout the year. The cone indexes below the 12-in. depth also were greater than 150. As shown above, a cone index value of 90 is the highest value which was required for continuous operation of a vehicle.

WES slope site

41. Cone index minimum values for the 6- to 12-in. layer at the WES slope site were approximately 50 to 70. This range is adequate for practically all the vehicles except the towing vehicles pulling heavy loads. These minimum conditions were obtained very infrequently, and when they occurred were always supported by values of 150 or greater at approximately 14 in. In general, this site (neglecting the gradient feature) is considered to have been trafficable to all vehicles for the period reported. The minimum values quoted above would have permitted deep rutting of the heaviest vehicles but the 150 value at 14 in. would have sustained their traffic.

Mound site

42. Determination of the trafficability at this site is comparatively

difficult because the 18-in. cone index value was lower than the 6- to 12-in. values. Study of the cone index data in table 5 reveals some cases where the ability of some vehicles to travel might be doubtful. The worst conditions shown are those on 10 February. These are listed below.

Depth - Inches	0	3	6	12	18	24	30	36+
Cone Index	49	95	109	79	51	74	107	150

The most conservative evaluation of average cone index for this condition would necessarily include the 18-in. value and would be 50 to 80, with an average of 65. A value of 65 is adequate for all nontowing vehicles and for all tractors towing 10 per cent loads, but not for tractors towing 50 per cent loads. The condition given constitutes a border-line condition for the latter vehicles. The high values to 6 in. would play a part in the support of the tractors for a few passes, but if something occurred to check the progress, the tracks of the towing vehicle would rapidly cut through to the 50 cone index and the vehicle would become immobilized. In the early part of 1949 vehicles were operated at the Mound site in an area whose average cone index corresponds approximately to the example given except that the 18-in. cone index was as high or higher than the values at 6 to 12 in. Tests were run with five vehicles, and while travel was often labored, none of the vehicles was immobilized. In another area, which had been used for a borrow pit the previous year, the cone index was approximately 45 to 65. In this area, the 2-1/2-ton truck was immobilized, but the D7 tractor (at no load) and the M24 tank were able to complete a substantial number of passes.

Remolding

43. In recent tests on natural soil conditions, it was discovered that in some cases initially high cone indexes capable of supporting a vehicle may become lower as a result of the action of repeated traffic. This detrimental remolding was found to occur in soils of the same general type as those at the WES sites and the Rifle Range site, but not in the soil at the Mound site. Preliminary indications are that detrimental remolding usually occurs when the per cent saturation of the soil is in excess of 90 and the cone index is 100 or less, except that highly plastic soils fail to remold even when completely saturated. Only limited analysis has been performed, and the figures are subject to more complete study which may alter them or establish other more satisfactory criteria.

PART IV: CONCLUSIONS AND RECOMMENDATIONS

44. On the basis of the test results and observations, the following conclusions are made:

a. Soil moisture shows a definite seasonal variation, increasing with rainfall and decreasing during periods of no rainfall, with natural limiting maximum and minimum values.

b. The cone index also shows a seasonal variation following a similar pattern to that for soil moisture, except that rainfall decreases the cone index and dry periods produce an increase in cone index.

c. No simple relationships between rainfall, temperature, soil moisture, and cone index were found, but correlations were developed for the specific periods for which observations were made.

d. The relationship between moisture content and cone index is very general.

e. A definite soil profile exists at the Mound site which causes variation in soil strength below 18-in. depth.

f. Moisture contents in the sloping and flat sites show very good agreement, but the surface soil to a depth of about 12 in. had been disturbed recently at the slope site which may have affected the test results.

45. The following recommendations for future testing are made:

a. Data from sites where generally lower cone indexes are to be found may yield more useful information and selection of such sites for testing is recommended.

b. Information relative to soils which have given trafficability trouble in the past should be collected and studied.

c. If better means of predicting critical trafficability factors cannot be found, it is recommended that the method suggested in paragraphs 28 to 31 be developed.

d. Determination of natural moisture and cone index limits for various other soils in various other climates should be undertaken.

TABLES

Table 1

TEMPERATURE AND RAINFALL DATA
8 AUGUST 1948 TO 8 AUGUST 1949

August 1948

Date	Vicksburg Weather Station		Mound Site		Rifle Range Site		WES Sites	
	Temp.	Rain.	Temp.	Rain.	Temp.	Rain.	Temp.	Rain.
8-8-48	78	.22				.20		-
9	74	5.11		7.50		5.12		-
10	76	1.10		1.00		1.00		-
11	80							-
12	84							-
13	85	.40				.20		.20
14	84							
15	80	2.14		1.57		2.80		2.15
16	76	.88		.83				
17	78							
18	80							
19	82							
20	82							
21	84							
22	84							
23	83							
24	80							
25	82	.17						.20
26	80							
27	83							.12
28	82			.40		.20		
29	83			.19				
30	82							
31	81							
Average	81.0							
Total		10.02		11.49		9.52		2.67

September 1948

9-1-48	79							
2	80							
3	79							
4	70	.26		.50		.30		.35
5	75							

Table 1 (Cont'd)

September 1948 (Cont'd)

Date	Vicksburg Weather Station Temp.	Vicksburg Weather Station Rain.	Mound Site Temp.	Mound Site Rain.	Rifle Range Site Temp.	Rifle Range Site Rain.	WES Sites Temp.	WES Sites Rain.
6	80							
7	80							
8	82							
9	76	.06						.04
10	66	.14		.18		.15		.15
11	72							
12	74	.04		.10		.20		.06
13	70	.58		.61		.54		.68
14	74							
15	76							
16	80							
17	77							
18	79							
19	78							
20	78							
21	77							
22	80			.04		.10		
23	76							
24	70							
25	63						64	
26	61						64	
27	64	.08		.04		.20	65	
28	58	.39		.30		.70	59	.53
29	61						59	
30	69						67	
Average	73.5						63.0	
Total		1.55		1.77		2.19		1.81

October 1948

10-1-48	74						70	
2	70						68	
3	67						67	
4	60						61	
5	64						62	
6	66		74				66	
7	66	.05	72	.03		.03	61	.03

Table 1 (Cont'd)

October 1948 (Cont'd)

Date	Vicksburg Weather Station Temp.	Vicksburg Weather Station Rain.	Mound Site Temp.	Mound Site Rain.	Rifle Range Site Temp.	Rifle Range Site Rain.	WES Sites Temp.	WES Sites Rain.
8	66		65				62	
9	68		61				63	
10	71	.38	68	.38		.44	69	.45
11	66		66		68		68	
12	66		61		63		63	
13	68		60		62		62	
14	68	.27	65	.32	64	.30	67	.28
15	72		68		70		68	
16	74		69		67		72	
17	54	.12	51	.34	45	.01	55	.02
18	49						55	
19	54		50		51		55	
20	62		52		55		59	
21	64		58		58		62	
22	66		57		60		62	
23	65		57		60		60	
24	58		54		55		57	
25	60		55		56		57	
26	62		58		60		59	
27	68		60		63		63	
28	66		58		61		61	
29	70		61		63		65	
30	69		64		65		68	
31	74		72		75		75	
Average	65.4		61.4		61.1		63.3	
Total		0.82		1.07		0.78		0.78

November 1948

11-1-48	68	5.31	68	5.75	66	2.75	68	3.42
2	68	.01	66	.20	67	1.60	69	.20
3	66		62		63		64	
4	70		72		72		69	
5	66	1.29	61	1.13	65	1.54	64	2.05
6	57		53		57		56	
7	60		50		54		54	
8	61		56		59		55	
9	58	.01	57		59		58	

Table 1 (Cont'd)

November 1948 (Cont'd)

Date	Vicksburg Weather Station		Mound Site		Rifle Range Site		WES Sites	
	Temp.	Rain.	Temp.	Rain.	Temp.	Rain.	Temp.	Rain.
10	48		43		48		45	
11	54		47		47		45	
12	55	.03	52	.05	52	.05	50	.06
13	56		55		56		54	
14	56	.04	56	.06	57	.05	56	.05
15	62		62		66		59	
16	64	1.55	65	1.43	64	1.83	64	1.45
17	63		62		60		66	
18	68	3.86	67	4.16	60	4.50	66	5.04
19	54		53		55		54	
20	54		54		50		54	
21	58	.46	58	.64	55		59	.64
22	50		53		48		50	
23	47		46		43		44	
24	50		45		46		48	
25	57		57		51		53	
26	60	1.68	60	1.45	57	1.80	57	1.96
27	57	.97	56	1.35	55		56	1.20
28	50	1.07	50	.76	50	1.98	51	.80
29	42		40		39		41	
30	46		40		43		43	
Average	57.5		55.5		55.5		55.7	
Total		16.28		16.98		16.10		16.87

December 1948

12-1-48	52		42		43		44	
2	56	.04	52	.08	50		52	.05
3	54		49		48		50	
4	58		55		53		54	
5	58	.12	56	.15	54	.26	54	.15
6	52		48		46		47	
7	56		56		55		56	
8	48		41		45		46	
9	47		43		43		45	
10	42		39		33		42	
11	52		51		45		48	

Table 1 (Cont'd)

December 1948 (Cont'd)

Date	Vicksburg Weather Station		Mound Site		Rifle Range Site		WES Sites	
	Temp.	Rain.	Temp.	Rain.	Temp.	Rain.	Temp.	Rain.
12	66		60		63		66	
13	68		67		70		66	
14	70		69		70		71	
15	72	.01	62		72	1.70	73	
16	63	2.67	65	1.57	61	.90	62	2.84
17	53	.01	54		52		54	
18	54	.24	55	.17	54	.08	55	
19	49		50		45	.05	47	.16
20	49		48		48		46	
21	62		61		63		62	
22	58		56		54		55	
23	52		50		50		52	
24	59	.54	60	.63	57	.47	60	.57
25	40		39		38		39	
26	30		38		33		32	
27	42		43		40		41	
28	57		58		57	.72	56	.88
29	48	1.07	46	.93	48		48	
30	38		37		36		38	
31	40		34		35		36	
Average	53.1		51.1		50.4		51.5	
Total		4.70		3.53		4.18		4.65

January 1949

1-1-49	44		40		38		40	
2	46	1.10	53	1.10	55		55	.91
3	66	.96	68	.95	67	2.13	67	1.00
4	60	1.34	63	.90	60	1.70	59	1.62
5	43	.37	44	.22	43	.30	44	.42
6	46		43		45		44	
7	52		46		45		47	
8	60		49		45		57	
9	66		63		62		64	
10	68		61		60		64	
11	59		54		58		59	
12	50		50		50		51	

Table 1 (Cont'd)

January 1949 (Cont'd)

Date	Vicksburg Weather Station		Mound Site		Rifle Range Site		WES Sites	
	Temp.	Rain.	Temp.	Rain.	Temp.	Rain.	Temp.	Rain.
13	56		54		53		55	
14	62		58		58		60	
15	66		65		62		65	
16	60	1.92	63	2.40	56	3.20	61	2.19
17	43	1.08	45	.92	57	.13	46	1.06
18	54	.29	52	.23	51	.23	54	.18
19	40		39		38		40	
20	40		40		40		40	
21	46	2.20	42	1.75	46	2.42	47	2.10
22	52	.24	54	.24	52		52	.16
23	66	.06	66	.06	65		66	
24	72		71		70		72	
25	70		68		65		69	
26	65	.02	61		65		67	
27	61	.10	59	.20	60	.20	58	.17
28	42		45		44		44	
29	30		30		29		31	
30	22	1.10	24	.50	23	.50	23	.50
31	28		25	.34	22		25	
Average	52.7		51.5		51.5		52.5	
Total		10.78		9.81		10.81		10.31

February 1949

2-1-49	30		35		35		27	.60
2	40		36		35		37	.64
3	51	.77		1.10	50	.62	46	.19
4	50	.03			45	.08	46	
5	46				40		43	.05
6	50	.01			45	.03	49	
7	48		47		45		50	
8	59	.01	55		54	.05	54	.04
9	54	2.01	56	2.03	57	1.70	54	2.13
10	48		45		42	.04	43	.30
11	50		47		48		46	
12	61		61		60		60	
13	72		71		70		72	

Table 1 (Cont'd)

February 1949 (Cont'd)

Date	Vicksburg Weather Station		Mound Site		Rifle Range Site		WES Sites	
	Temp.	Rain.	Temp.	Rain.	Temp.	Rain.	Temp.	Rain.
14	73		73		72		74	
15	61	.30	60	.60	63	.40	63	.35
16	54		53		50	.04	52	
17	52		50		47		47	
18	52	.65	51	.52	55	.60	57	.06
19	58	.24	54	.73	57	.36	55	.87
20	58		55		58	.10	56	
21	59	.15	59	.20	60		57	.09
22	64		62		60		59	
23	60		57		58		56	
24	64	.65	61	.85	64	.80	62	.92
25	59		56		58		57	
26	50	.52	50	.62	51	.66	51	.98
27	54		53		57		53	
28	42		44		45		43	
Average	54.3		53.7		52.9		52.5	
Total		5.34		6.65		5.48		7.22

March 1949

3-1-49	44		44		46		43	
2	48		46		48		46	
3	51		46		49		46	
4	56		50		53		51	
5	61		60		55		58	
6	62	.03	62		62		61	
7	50		49	.07	50		50	
8	57		55		63	.42	55	
9	56	.23	61	.25	56		62	.50
10	47		47		50		50	
11	48		47		50		47	
12	58		58		55		53	
13	62	.28	61	.17	65	.38	63	.52
14	49	1.51	50	.80	50	1.48	47	1.25
15	45		48		44		44	
16	51		53		52		50	
17	64		65		65		64	

Table 1 (Cont'd)

March 1949 (Cont'd)

Date	Vicksburg Weather Station		Mound Site		Rifle Range Site		WES Sites	
	Temp.	Rain.	Temp.	Rain.	Temp.	Rain.	Temp.	Rain.
18	52	.05	45	.03	50	.08	46	.08
19	48		45		45		43	
20	58		58		55		53	
21	64	.79	64	1.90	65	.97	65	.98
22	58		58		57		55	
23	60		57		57		55	
24	64	.38	66		66		62	.53
25	70	2.92	72	2.80	72	2.77	71	2.28
26	73	1.11	73	1.00	75	2.24	73	1.77
27	60	.77	58	.80	60	.41	60	.92
28	60		60		60		59	
29	65	.36	64	.45	66	.35	65	.40
30	72		70	.45	73	.35	72	.35
31	66	.47	64		66		64	
Average	57.4		56.6		57.4		55.9	
Total		8.90		8.72		9.45		9.58

April 1949

4-1-49	57		57		59		57	
2	54		54		55		55	.05
3	55		55		57	.03	56	
4	54		54		57		55	
5	56	.03	55		57		50	.05
6	63		63		60		60	
7	70		67		70		69	
8	70		71		70		70	
9	68		65		67		65	
10	63	.34	63	.35	65	.52	64	.54
11	64	.09	63		65	.06	64	.05
12	56	.31	58	.20	58	.40	56	.37
13	62		62		62		62	
14	69		68		70		68	
15	56		55		54		58	
16	55		50		55		61	
17	60		55		57		62	
18	64		53		63		60	

Table 1 (Cont'd)

April 1949 (Cont'd)

Date	Vicksburg Weather Station		Mound Site		Rifle Range Site		WES Sites	
	Temp.	Rain.	Temp.	Rain.	Temp.	Rain.	Temp.	Rain.
19	60		57		59		57	
20	57	.14	58	.10	58		57	
21	62	.01	63	.10	65	.05	63	
22	64	.22	63	.20	63	.09	62	.21
23	68		66		68		68	
24	76		71		75		73	
25	74		66		70		73	
26	74	.35	74	.10	75	.40	74	.40
27	69	2.79	70	3.20	71	3.30	71	3.30
28	68	.01	69	.17	70	.26	69	.25
29	70	.38	68	.17	70	.06	71	.14
30	72		71		72		72	.01
Average	63.7		62.1		63.9		63.4	
Total		4.67		4.59		5.17		5.37

May 1949

5-1-49	70	.49	70	.61	76	.74	72	.59
2	74		74		78		75	
3	78		76		78		76	
4	78		74		76		75	
5	79		74		76		74	
6	78		73		76		74	
7	78		74		75		74	
8	78		74		76		75	
9	76		76		78		76	
10	67		67		69		68	
11	66		65		68		66	
12	66				66		66	
13	73				70		69	
14	73				70		71	
15	74				70		71	
16	74		75		76		73	
17	75		75		78		74	
18	76		75		77		78	
19	77		75		81		76	
20	79		77		78		79	

Table 1 (Cont'd)

May 1949 (Cont'd)

Date	Vicksburg Weather Station		Mound Site		Rifle Range Site		WES Sites	
	Temp.	Rain.	Temp.	Rain.	Temp.	Rain.	Temp.	Rain.
21	77		76		82		78	
22	80		79		82		80	
23	79	.02	78		82		81	.04
24	76		76		76		75	
25	72		68		73		70	
26	74		69		71		70	
27	77		73	.55	77		76	
28	73	.67	72	.05	75	.05	74	.18
29	74	1.37	73	1.10	78	.45	76	.83
30	76	.14	73	.07	79	.52	77	.39
31	72	.02	72	.31	76		74	
Average	74.8		73.4		75.6		73.9	
Total		2.71		2.69		1.76		2.03

June 1949

6-1-49	79	.25	76		83		78	.04
2	78		77		80		75	
3	78		76		77		75	
4	80		76		80		76	
5	78		76		80		78	
6	82		78		84		79	
7	81	.08	80	2.20	84	.44	80	1.82
8	76	.89	75	.50	80	1.40	76	.12
9	78	.23	76	1.00	81	.30	78	.28
10	76		75		79		76	.01
11	78	.52	77		81	.36	78	.36
12	78	.20	76	.63	82	.78	79	.10
13	80		79		83		81	.02
14	76	.98	75	.55	79	.54	76	.32
15	76		75		80		77	.01
16	76		74		79		74	
17	76		75		78		75	
18	80		78		81		78	
19	82	.02	79		82	.12	80	.03
20	80		81		80		80	.01
21	81		80		83		81	

Table 1 (Cont'd)

June 1949 (Cont'd)

Date	Vicksburg Weather Station		Mound Site		Rifle Range Site		WES Sites	
	Temp.	Rain.	Temp.	Rain.	Temp.	Rain.	Temp.	Rain.
22	83	.05	79	.93	84	.36	82	.02
23	82		80		83		80	
24	79	.15	78		80		78	.08
25	83		81		85		82	
26	83	.22	80		85	.22	82	.42
27	82		82		84		82	
28	83		81		85		83	
29	85		81		85		83	
30	82	.16	81		86	.10	83	.06
Average	79.7		77.9		81.8		78.8	
Total		3.75		5.81		4.62		3.70

July 1949

7-1-49	82	.20	82	.21	86	.66	82	.94
2	82		81		84	.02	81	
3	76	.10	77	.10	81	.08	76	.09
4	80	.20	82	.32	76	.12	80	.33
5	81		79		80		81	
6	85		81		86		84	
7	85		82		83		82	
8	84		81		84		82	
9	85		82		84		85	
10	85		81		84		85	
11	85	.13	83	.20	88	.04	85	
12	82	.68	85	.40	84	.24	83	.20
13	80	.52	83	.65	82	.76	81	.31
14	79		80		80		79	
15	80		79		79		80	
16	77	.59	80		80	.18	79	.11
17	79		78		78		79	
18	83		78		80		83	
19	82	.21	79	.40	81	1.10	82	.68
20	82		77	.13	79		81	
21	82	.08	76	.24	78		80	
22	80	.15	77	.12	79		80	.02
23	80	.57	75		77		79	.26

Table 1 (Cont'd)

July 1949 (Cont'd)

Date	Vicksburg Weather Station		Mound Site		Rifle Range Site		WES Sites	
	Temp.	Rain.	Temp.	Rain.	Temp.	Rain.	Temp.	Rain.
24	77	.49	72	1.50	74	.25	77	.44
25	80		73		75		80	
26	81		78		80	.20	80	.06
27	80		73	.15	75	.52	79	
28	82		78		80		81	
29	84		78		80		82	
30	85		79		81		83	
31	80	3.10	76	.50	78	1.74	80	2.86
Average	81.5		78.9		80.5		81.0	
Total		7.02		4.92		5.91		6.30

August 1949

8-1-49	77		71		73		77	
2	78		72		74		74	
3	80		73		75		77	
4	79		73		75		77	
5	80		74	.07	76		79	.01
6	80	.07	75	.21	77		80	.02
7	80		78		80	.05	81	.19
8	81		84		84		84	
Average	79.4		75.0		76.8		78.6	
Total		0.07		0.28		0.05		0.22

Table 2

CONE INDEX, MOISTURE CONTENT, AND DENSITY DATA

WATERWAYS EXPERIMENT STATION FLAT SITE

Date	Cone Index								Moisture Content						Density				
	Depth																		
	0	3	6	12	18	24	30	150 CI	0-1	1-6	6-12	12-18	18-24	24-30	0-6	6-12	12-18	18-24	24-30
8-16-48	49	150						1		29.6									
8-18-48	98	150						1		25.5	22.3	24.6			95.3	100.8			
8-25-48	150							0		14.9	24.1	24.6			90.4	81.8			
9- 1-48	150							0		10.0	18.4	22.8			82.9	89.1			
9- 8-48	150							0		8.6	15.6	19.9	14.9	16.9	91.7	96.0	94.7	96.1	95.0
9-14-48	150							0		21.1									
9-16-48	150							0		14.1	13.3				91.1				
9-20-48	150							0		10.4	12.9	18.6			87.6	95.8			
9-23-48	150							0		6.3	16.0	18.3			94.0	99.3			
9-27-48	150							0		5.9	14.4	18.1	18.8		95.0	103.6	96.2		
9-30-48	150							0		14.2	11.8	18.5			89.2	97.8			
10- 4-48	150							0	7.5	10.6	12.7				93.5				
10- 8-48	150							0	6.0	7.3	11.4	12.7			90.8	96.8			
10-11-48	121	150						0	20.7	12.3	6.9				86.1				
10-14-48	61	150						2	18.3	10.4	12.2	19.8							
10-19-48	150							0	13.6	11.2									
10-21-48	150							0	11.9	10.3	9.8				88.4				
10-25-48	146	150						0	8.3	10.9									
10-28-48	150							0	9.0	8.2									
11- 2-48	35	150						2	33.0	26.7	22.2	18.6	22.2			99.9	95.5		
11- 8-48	110	150						1	30.9	25.2	21.7	22.7			90.2	98.3			

Note: Underlined values are averages for less than three samples.

Table 2 (Cont'd)

Date	Cone Index								Moisture Content						Density				
	0	3	6	12	18	24	30	Depth 150 C I	0-1	1-6	6-12	12-18	18-24	24-30	0-6	6-12	12-18	18-24	24-30
11-15-48	95	150						1	26.5	25.1	22.8	22.7	23.6		88.5	97.3	100.5		
11-17-48	73	150						2	30.3	25.1	23.4	23.0	21.9		94.4	97.7	98.3		
11-19-48	51	150						2	35.8	28.7	23.9	25.1	21.9		87.1	97.3	97.9		
11-22-48	54	150						2	34.6	29.9	21.9	23.3	24.9		90.9	100.2	102.1		
11-29-48	60	150						2	36.1	27.4	23.7	24.9	25.0		89.3	98.6	99.8		
12- 2-48	140	150						1	32.4	29.8	22.1	24.4	25.2		86.2	99.7	99.4		
12- 6-48	106	150						3	36.0	29.3	23.7	24.9	25.5		89.7		99.1	99.2	
12- 9-48	150							0	33.7	27.4	24.5	26.1	15.1		92.5	97.9	96.7		
12-13-48	145	150						1	30.8	26.0	22.5	21.3							
12-16-48	135	150						1	31.8	29.2									
12-20-48	150							0	31.7	28.3	23.4	24.5			87.9	97.0			
12-21-48	-	-	-	-	-	-	-	-		27.1	25.2	25.8	26.5	26.2	89.7	96.4	95.0	95.3	95.8
12-27-48	137	150						1	31.8	27.2	23.3	25.2			90.9	98.2			
12-30-48	150							0	33.6	25.9	24.5	25.7			92.0	100.7			
1- 3-49	150							0	33.6	25.7					93.7				
1- 5-49	109	150						2	33.8	27.1	24.0	25.8	26.3						
1-10-49	150							0	29.1	27.1	22.1	23.7	26.0		90.0	101.2	98.1		
1-13-49	150							0	30.1	24.9	22.6	23.4			91.7				
1-18-49	80	150						2	37.1	28.4	23.5	26.8	26.0		88.7	98.7	93.9	99.7	
1-20-49	128	150						1	31.5	25.2	24.4				92.0				
1-24-49	116	150						1	33.1	27.5	23.9				88.9				
1-26-49	107	150						1	34.0	26.9	24.3	25.8	26.5	26.7	90.1	96.8	95.7		
2- 7-49	119	150						1	32.0	27.3	24.4	25.1			90.6	94.7			
2-10-49	78	150						1	34.1	27.1	28.3				86.7				
2-14-49	150							0	31.2	25.6	22.8				92.2				
2-17-49	144	150						1	30.7										

Note: Underlined values are averages for less than three samples.

Table 2 (Cont'd)

Date	Cone Index								Moisture Content						Density				
	0	3	6	12	18	24	30	Depth 150 C I	0-1	1-6	6-12	12-18	18-24	24-30	0-6	6-12	12-18	18-24	24-30
2-21-49	95	150						2	34.0	31.7									
2-28-49	140	150						2	30.6	27.8	23.5				90.5				
3- 3-49	150							0	34.3	28.1	24.2	24.4			88.2	93.8			
3- 5-49	150							0	29.0	24.3									
3-10-49	150							0	29.4	25.1	23.5				89.6				
3-15-49	150							0	30.7	29.2	25.5	29.1			88.1	90.3			
3-17-49	150							0	28.9	27.2	23.8				87.6				
3-22-49	119	150						1	34.4	28.5	27.7				86.2				
3-28-49	119	150						1	30.7	22.9	23.9	26.2	26.1	25.1					
4- 4-49	150							0	33.0	26.8									
4- 8-49	150							0	26.3	23.2	23.7								
4-11-49	150							0	29.7	25.9	22.5				90.1				
4-15-49	140	150						1	28.0	23.0	24.5	26.8	33.1		94.0	99.2	93.7	88.2	
4-18-49	150							0	23.6	19.2	21.2				91.2				
4-25-49	150							0	22.4	20.5									
4-28-49	100	150						3	37.0	27.5	23.2	24.4			88.2	100.2			
5- 2-49	123	150						1	33.8	25.7	23.5	24.8	25.5		91.3	99.7			
5- 9-49	150							0	22.0	19.4	20.8				85.4				
5-16-49	150							0	8.7										
5-23-49	150							0	2.5	6.5									
5-31-49	150							0	24.5	20.3									
6- 6-49	150							0	6.7	11.4	13.6	15.1	17.9						
6-13-49	150							0	30.2	26.6									
6-20-49	150							0	17.5	19.7									
6-27-49	150							0	20.1	17.7									
7- 5-49	150							0	23.7	21.3									

Note: Underlined values are averages for less than three samples.

Table 2 (Cont'd)

Date	Cone Index								Moisture Content						Density				
	0	3	6	12	18	24	30	Depth 150 C I	0-1	1-6	6-12	12-18	18-24	24-30	0-6	6-12	12-18	18-24	24-30
7-11-49	150							0	5.1	8.9	13.4	18.3	19.9						
7-18-49	150							0	8.6	12.6	18.1	20.6	21.9		88.1	92.0	90.6	94.6	
7-25-49	150							0	22.7	20.1	17.7				93.4				
8- 1-49	109	150						2	30.1	25.6	19.3				85.9				
8- 8-49	150							0	18.6	17.3									

Note: Underlined values are averages for less than three samples.

Table 3

CONE INDEX, MOISTURE CONTENT, AND DENSITY DATA

WATERWAYS EXPERIMENT STATION SLOPE

Date	Cone Index								Moisture Content						Density				
	0	3	6	12	18	24	30	Depth 150 C I	0-1	1-6	6-12	12-18	18-24	24-30	0-6	6-12	12-18	18-24	24-30
8-16-48	38	46	100	150				9		30.0	30.8	26.2			83.8	84.6	91.4		
8-18-48	75	73	88	119	150			13		28.3	25.9	26.4	24.6		86.6	89.2	87.0		
8-25-48	134	141	150					3		17.6	19.8	22.6	24.0		80.8	80.4	88.9	90.4	
9- 1-48	150							0		12.1	15.1	18.2	18.8		84.7	78.9	85.0		
9- 9-48	150							0		9.6	12.0	13.7	16.1	14.3	83.8	87.2	88.8	93.7	92.8
9-14-48	133	150						1		18.9	10.9	13.8			83.1	80.3	72.0		
9-16-48	140	150						2		15.2	10.1	10.8			80.8	83.0			
9-20-48	89	138	150					5		11.9	10.4	10.4	15.8		79.2	81.7	78.0		
9-23-48	138	150						2		8.5	10.9	10.3			86.4	86.0			
9-27-48	150							0		9.4	11.0	11.1	9.5		77.6	82.0	70.9	81.6	
9-30-48	130	150						1		15.2	10.0	15.7	20.5		78.7	82.0	91.2		
10- 4-48	150							0	13.2	13.0	9.8	11.6	11.9		79.5	78.8	83.6		
10- 8-48	150							0	7.6	10.9	9.6	10.3			79.8	89.5	81.2		
10-11-48	59	150						2	20.6	13.1	10.3	9.9	8.4		82.5	84.7	80.7		
10-14-48	92	150						1	21.3	14.3	9.3	9.9			80.3	83.2			
10-19-48	150							0	15.2	14.8	11.2	13.6			77.6	74.3			
10-21-48	107	150						1	9.9	12.4	10.3	11.0	9.5		81.9	80.0	79.8		
10-25-48	110	150						1	5.0	10.2	9.6	7.9	11.9		78.6	84.3	81.5		
10-28-48	113	150						1	8.0	10.8	13.2	8.8			76.6	73.0	83.3		
11- 2-48	45	73	124	150				7	27.8	24.2	17.2	14.2	17.1		88.5	85.6	90.4	100.7	
11- 8-48	75	92	135	150				7	27.6	26.1	22.3	16.2			81.2	87.2	76.5		

Note: Underlined values are averages for less than three samples.

Table 3 (Cont'd)

Date	Cone Index								Moisture Content						Density				
	0	3	6	12	18	24	30	Depth 150 C I	0-1	1-6	6-12	12-18	18-24	24-30	0-6	6-12	12-18	18-24	24-30
11-12-48	128	109	150					5	25.4	25.1	24.4	19.6	16.9		86.3	90.7	92.9	91.9	
11-15-48	61	86	124	150				8	26.7	25.6	26.1	23.8	22.0		86.1	87.4	92.1		
11-17-48	38	51	98	126	150			14	31.5	31.3	24.8	23.3	21.3		81.1	90.3	95.9	102.2	
11-22-48	48	60	87	95	150			13	30.3	30.2	28.1	23.8	25.7		82.6	88.4	92.0	87.3	
11-29-48	44	62	70	150				10	27.8	28.4	26.3	24.4	24.0		86.0	91.7	95.4	93.1	
12- 2-48	96	66	53	120	150			13	24.3	27.6	27.6	24.6	25.4		84.6	87.9	94.3	88.0	
12- 6-48	76	89	84	88	150			14	29.8	26.5	25.7	23.9	23.1		85.0	85.7	96.2		
12- 9-48	91	73	72	126	150			14	29.9	30.9	29.3	23.8	24.7		83.7	81.6	95.1	95.7	
12-13-48	81	80	84	108	150			16	28.3	28.6	26.8	26.3	22.1		82.2	87.9	74.7		
12-16-48	46	66	92	150				11	29.2	28.6	25.0	25.3	28.8		86.4	93.6	88.1	88.3	
12-20-48	71	58	103	150				10	30.8	32.3	28.4	25.2	26.7		82.8	87.8	95.6	95.3	
12-27-48	83	77	61	94	139	150		19	31.2	28.7	27.5	26.9	25.8	29.1	85.2	89.7	86.5	90.7	
12-30-48	111	102	102	150				8	29.4	27.4	27.4	24.6			85.7	90.1	97.8		
1- 3-49	81	77	115	150				10	30.6	28.7	26.6	26.0			88.4	90.6	94.3		
1- 5-49	43	60	71	96	150			13	31.0	28.2	27.4	25.2	28.7		86.6	87.8	89.0	88.0	
1-10-49	70	61	49	123	150			14	30.4	29.1	27.2	29.2	26.6		84.7	89.0	91.6	93.6	
1-13-49	92	72	90	150				9	30.8	29.1	28.6	27.3			86.0	86.5	90.9		
1-18-49	54	75	75	72	150			13	32.3	27.5	26.3	26.9	28.5		84.2	89.6	90.9	91.0	
1-20-49	96	81	110	150				9	30.0	28.6	27.6	27.2	26.8		87.6	89.0	87.1	88.7	
1-24-49	66	61	91	150				10	34.0	28.6	26.6	26.3	26.2		83.0	93.6	82.6	89.0	
1-26-49	59	55	80	150				11	30.9	27.6	25.8	24.0	25.0		86.7	91.1	97.4	92.0	
2- 3-49	56	54	66	66	150			14	34.7	31.6	30.5	30.5	24.6		80.9	81.6	78.8		
2- 7-49	68	96	96	150				11	33.8	29.5	26.9	29.9	26.8		87.2	88.6	84.7	89.2	
2-10-49	49	60	55	150				12	40.5	30.5	30.8	28.1	29.0		85.2	83.4	89.0	86.7	
2-14-49	104	65	71	106	150			13	33.8	28.5	28.5	26.6	26.0		84.6	84.5	91.4		
2-17-49	80	80	75	117	150			13	31.1	29.1	30.5	26.2			84.8	86.3			

Note: Underlined values are averages for less than three samples.

Table 3 (Cont'd)

Date	Cone Index								Moisture Content						Density				
	0	3	6	12	18	24	30	Depth 150 C I	0-1	1-6	6-12	12-18	18-24	24-30	0-6	6-12	12-18	18-24	24-30
2-21-49	63	56	74	150				9	38.0	31.6	29.5	26.1	28.9		82.9	82.5	89.1	88.3	
2-28-49	67	59	69	133	138	150		23	38.7	31.5	26.9	26.7	27.2		83.7	82.4	92.9	90.4	
3- 3-49	94	78	101	150				9	28.4	27.9	27.8	25.7	26.9		86.6	86.3			
3- 5-49	144	150						1	28.2	24.5	25.6	29.2			88.4	84.0			
3-10-49	110	90	96	150				8	30.0	26.5	27.3	24.9			85.1	86.3			
3-15-49	124	79	98	150				10	30.0	30.2	26.2	25.6	27.8		85.5	87.5			
3-17-49	126	94	90	150				8	28.5	27.5	28.5	25.8			88.8	88.7			
3-22-49	103	82	71	81	150			13	22.6	28.1	27.4	25.0			87.8	94.1			
3-23-49	84	53	72	150				11	33.9	31.3	29.8	28.7	27.4	27.2	81.6	89.6	87.5	86.6	86.0
4- 4-49	117	86	96	150				9	28.6	26.9	27.6	25.3			87.0	88.9			
4- 8-49	143	126	126	150				7	26.6	23.0	25.1	18.8			85.2	90.0			
4-11-49	101	107	112	139	150			13	33.4	24.9	26.4	28.8			87.3	91.3			
4-15-49	150							0	27.1	24.4	26.9	21.4	24.6		83.2	88.5	92.6	91.5	
4-18-49	150							0	19.3	18.2	23.6	25.0	27.2		84.8	82.8	85.2		
4-25-49	150							0	18.7	17.0	21.5	20.7			83.0	79.9			
4-28-49	85	111	125	150				9	35.6	27.5	26.3	25.3	21.9		88.5	88.6	93.8		
5- 2-49	117	136	150					5	33.8	28.8	24.1	23.4	24.8		85.9	89.3			
5- 9-49	150							0	15.6	17.2	23.5	23.0			87.8	91.6			
5-16-49	150							0	11.3										
5-23-49	150							0	3.9	7.9					84.8				
5-31-49	150							0	22.4	19.1									
6- 6-49	150							0	6.0	12.7	13.2	15.3	17.3		75.9	81.3	86.5		
6-13-49	138	150						2	26.5	24.0	21.0				89.5				
6-20-49	150							0	13.1	15.5	14.9	13.3			84.3	82.9			
6-27-49	150							0	16.4	14.9	17.0	17.3	21.0		86.4	85.9	80.0		
7- 5-49	146	150						1	23.6	21.4	14.2	11.9			68.0				

Note: Underlined values are averages for less than three samples.

Table 3 (Cont'd)

Date	Cone Index								Moisture Content						Density				
	0	3	6	12	18	24	30	Depth 150 C I	0-1	1-6	6-12	12-18	18-24	24-30	0-6	6-12	12-18	18-24	24-30
7-11-49	150							0	6.2	9.1	11.7	12.9	16.1		85.0				
7-18-49	150							0	15.3	14.5	13.3	15.8	19.1		87.3	87.1	92.5	92.8	
7-25-49	129	127	150					4	25.3	24.9	20.4	<u>25.9</u>	<u>25.6</u>		86.9	<u>93.6</u>	<u>83.6</u>	<u>84.0</u>	
8- 1-49	124	143	150					4	24.8	25.1	20.2	22.9			84.3	89.4			
8- 8-49	135	150						1	19.3	15.8	17.3				83.2				

Note: Underlined values are averages for less than three samples.

Table 4

CONE INDEX, MOISTURE CONTENT, AND DENSITY DATA

RIFLE RANGE SITE

Date	Cone Index								Moisture Content						Density				
	0	3	6	12	18	24	30	Depth 150 C I	0-1	1-6	6-12	12-18	18-24	24-30	1-6	6-12	12-18	18-24	24-30
8- 9-48	28	150						2		22.3									
8-10-48	24	150						2		25.7									
8-11-48	59	150						2		21.7									
8-16-48	15	150						1		25.9									
8-18-48	103	150						1		19.9	20.2				90.2				
8-25-48	150							0		4.9									
9- 1-48	150							0		6.9									
9- 8-48	150							0		12.8	13.1	15.9	18.9	21.9	101.8	100.4	94.1	89.5	88.3
9-14-48	150							0		19.4									
9-16-48	150							0		13.2									
9-20-48	150							0		9.0									
9-23-48	150							0		6.0									
9-27-48	150							0		8.1	10.9				106.2				
9-30-48	150							0		18.8									
10- 4-48	150							0	8.9	11.6									
10- 8-48	150							0		9.8									
10-11-48	150							0		17.7									
10-14-48	69	150						2	19.8	17.1									
10-19-48	150							0	12.5	15.4									
10-21-48	150							0	10.6	14.4									
10-25-48	150							0		10.7									
10-28-48	133	150						2	8.0	6.3									

Note: Underlined values are averages for less than three samples.

Table 4 Cont'd)

Date	Cone Index							Depth 150 C I	Moisture Content						Density				
	0	3	6	12	18	24	30		0-1	1-6	6-12	12-18	18-24	24-30	1-6	6-12	12-18	18-24	24-30
11- 1-48	150							0	5.2	10.1									
11- 2-48	28	150						2	21.2	21.3	20.1				105.2				
11- 8-48	138	150						1	18.7	18.9	18.5				105.1				
11-12-48	108	150						1	17.8	19.0									
11-15-48	83	150						1	18.1	17.4									
11-17-48	50	150						1	21.9	20.2	19.0				106.9				
11-23-48	31	150						2	34.2	24.4	21.0				102.6				
11-29-48	30	140	150					4	25.8	21.5	20.9				104.7				
12- 2-48	150							0	23.1	20.1									
12- 6-48	117	150						2	24.7	21.8	17.6				105.2				
12- 9-48	126	150						1	20.4	19.1									
12-13-48	136	150						1	26.6	18.7									
12-16-48	47	150						3	27.0	21.0									
12-20-48	148	150						1	22.0	21.1									
12-21-48	-	-						-		21.3	19.6	24.3	27.0	29.0	101.9	96.6	93.2	91.2	90.6
12-27-48	76	150						3	30.3	21.0					104.2				
12-30-48	150							0	24.5	22.6					105.1				
1- 3-49	48	150						3	24.5	22.4									
1- 5-49	32	150						2	31.8	27.1									
1-10-49	66	150						1	32.3	21.4									
1-13-49	111	150						3	23.5	19.1									
1-18-49	55	150						2	22.1	24.9									
1-20-49	63	150						3	32.6	21.9									
1-24-49	60	150						2	30.5	21.8	21.9				102.8				
1-26-49	45	150						2	27.6	21.3									
2- 3-49	32	150						3	27.7	21.9	21.4				102.6				

Note: Underlined values are averages for less than three samples.

Table 4 (Cont'd)

Date	Cone Index								Moisture Content						Density				
	0	3	6	12	18	24	30	Depth 150 C I	0-1	1-6	6-12	12-18	18-24	24-30	1-6	6-12	12-18	18-24	24-30
2- 7-49	49	150						2	23.4	24.6									
2-10-49	26	150						2	34.7	24.1									
2-14-49	121	150						1	27.2	19.6									
2-17-49	58	150						2	28.0	21.1									
2-21-49	45	150						2	34.1	24.5									
2-28-49	58	150						3	29.0	21.4					100.5				
3- 3-49	85	150						2	30.9	20.5									
3- 5-49	98	150						1	26.1	19.3									
3-10-49	78	150						2	28.3	20.4					108.3				
3-15-49	67	150						2	28.7	20.5									
3-17-49	118	150						1	26.3	20.5									
3-21-49	150							0	22.5	17.3									
3-22-49	68	150						1	25.6	18.6									
3-28-49	60	150						2	26.1	23.1	24.2	27.6	28.8	30.6					
4- 4-49	112	150						0	25.3	21.4									
4- 8-49	150							0	14.4	21.0	21.9								
4-11-49	150							0	28.4	22.8	22.7	25.0	27.8		100.2	99.7	92.6		
4-15-49	143	150						1	17.3	18.8									
4-18-49	150							0	11.5	16.7	21.7				101.6				
4-25-49	150							0	10.6	13.6									
4-28-49	91	150						3	34.8	24.9									
5- 2-49	90	150						3	35.2	21.7	22.3	24.2	26.2		105.0				
5- 9-49	150							0	9.1	13.7									
5-16-49	150							0	3.4	7.3									
5-23-49	150							0	2.7	3.7									
5-31-49	145	150						1	21.9	18.4									

Note: Underlined values are averages for less than three samples.

Table 4 (Cont'd)

Date	Cone Index								Moisture Content						Density				
	0	3	6	12	18	24	30	Depth 150 C I	0-1	1-6	6-12	12-18	18-24	24-30	1-6	6-12	12-18	18-24	24-30
6- 6-49	150							0	5.4	13.1	12.9	16.2	20.2						
6-13-49	93	150						2	25.4	21.1									
6-20-49	150							0	15.8	15.3									
6-27-49	150							0	17.2	13.5									
7- 5-49	145	150						0	26.1	16.2									
7-11-49	150							0	6.0	11.3	15.8	18.9	21.1						
7-18-49	133	150						0	17.8	17.6	17.5	20.6	23.6		96.2	95.9	89.2	88.5	
7-25-49	150							0	21.0	17.0									
8- 1-49	73	150						3	29.4	21.6									
8- 8-49	150							0	8.4	8.8									

Note: Underlined values are averages for less than three samples.

Table 5

CONE INDEX, MOISTURE CONTENT, AND DENSITY DATA

MOUND SITE

Date	Cone Index								Moisture Content						Density				
	0	3	6	12	18	24	30	Depth 150 C I	0-1	1-6	6-12	12-18	18-24	24-30	1-6	6-12	12-18	18-24	24-30
8- 9-48	46	150						3		33.5									
8-10-48	40	103	150					5		36.0									
8-11-48	52	108	115	112	99	95	150	25		33.6					72.7				
8-16-48	54	104	72	81	90	106	150	30		35.8	33.8				82.7	84.0			
8-18-48	73	125	132	98	77	91	113	36+		31.2	31.4				84.6	83.5			
8-25-48	150	150	150	111	96	105	113	36+		21.7	28.8				89.3				
9- 1-48	150							0		21.9	26.3	28.9	29.7		83.5	80.8	87.6		
9- 8-48	150							0		20.3	26.1	24.7	26.8	29.7	84.6	82.7	84.4	83.9	85.2
9-13-48	150							0		17.0					85.1				
9-14-48	129	150						1		29.7	24.6	25.4	27.9	34.3	87.1	82.1	83.3	78.8	79.8
9-16-48	150							0		23.0	24.5	24.7			87.5	90.0	84.9		
9-20-48	146	150						1		21.3	22.9	20.7			85.1	77.0			
9-23-48	148	150						1		21.4	24.7	22.2	26.6		87.0	83.8	82.3	83.2	
9-27-48	150							0		19.4	23.8	23.9	23.9		83.6	84.0	82.2		
9-30-48	145	150						1		19.9	22.8	21.4							
10- 4-48	150							0	23.1	20.2	22.8	23.4	22.8		87.1	86.4	82.5	81.2	
10- 8-48	150							0	16.2	16.4	24.1	21.8	21.5		89.1	88.4	87.6	77.4	
10-11-48	95	150						1	23.3	20.8	22.9	20.0	20.9		88.9	83.0	84.7	81.6	
10-14-48	72	142	150					4	25.0	23.9	24.5	23.4	21.1		85.9	84.3	83.0	80.7	
10-19-48	124	150						2	30.2	27.0	25.3	20.8	25.5		88.1	79.5	80.2	83.7	
10-21-48	150							0	26.1	22.0	23.8	21.8	20.4		89.6	85.5	84.2	84.9	
10-25-48	150							0	25.2	23.8	22.2	23.6	22.1		87.2	81.9	87.0		

Note: Underlined values are averages for less than three samples.

Table 5 (Cont'd)

Date	Cone Index								Moisture Content						Density				
	0	3	6	12	18	24	30	Depth 150 C I	0-1	1-6	6-12	12-18	18-24	24-30	1-6	6-12	12-18	18-24	24-30
10-28-48	95	150						1	14.7	22.9	24.9	22.8	20.1		86.2	82.1	78.6	76.9	
11- 1-48	150							0	12.9	20.5	22.8	20.9	19.1		84.8	87.1	81.7	82.7	
11- 2-48	40	102	112	105	100	150		22	35.8	29.1	31.6	31.6			90.7	90.6			
11- 8-48	75	126	132	117	118	150		22	35.8	29.9	32.7	31.2			90.3	88.8			
11-12-48	58	111	114	91	67	86	102	36+	34.9	31.1	32.6	31.3	34.4		86.4	88.0	87.5	85.5	
11-15-48	57	135	143	150				11	34.1	30.4	29.8	29.6			87.6	91.8			
11-17-48	45	88	96	97	67	83	104	36+	35.7	31.3	30.1	31.9	33.9		89.3	91.0	89.4	86.1	
11-19-48	25	83	118	139	150			17	44.1	33.7	32.4	33.1	33.6		85.5	88.2	86.3	87.0	
11-23-48	70	115	132	101	70	95	111	35	41.1	32.7	33.8	30.7	33.3		85.9	85.7	89.6		
11-29 48	37	92	116	114	94	109	150	27	45.1	33.3	33.6	35.3			86.4	87.7			
12- 2-48	92	114	131	126	121	150		20	39.5	32.5	34.5				86.9				
12- 6-48	94	109	114	87	94	107	150	27	38.8	34.9	33.1	33.6	34.9		85.2	87.6	86.6	82.7	
12- 9-48	90	128	137	101	81	96	124	33	37.6	33.4	34.0	36.0	37.2		88.0	82.2	82.9	83.5	
12-13-48	92	119	128	99	89	105	120	36+	39.6	33.1	33.1	32.3			84.9	84.9			
12-16-48	98	119	127	110	101	150		21	34.9	32.5	35.8				86.8				
12-20-48	110	118	114	112	111	120	150	25	38.2	32.8	33.9	32.4	36.6	35.7	85.8	85.8	87.2	83.4	
12-21-48	-	-	-	-	-	-	-	-		32.7	32.6	33.8	36.7	35.8	85.9	84.3	78.1	82.7	83.5
12-27-48	89	126	132	104	76	107	125	35	40.7	34.7	34.1	33.1	34.8	35.8	89.7			82.6	83.9
12-30-48	62	118	129	117	97	94	150	28	40.3	33.4	32.9	34.9	34.7	36.2	85.4	88.4			
1- 3-49	102	112	128	111	86	104	127	31	36.9	31.1	34.6	35.1	37.4		85.3	86.5	89.9		
1- 5-49	60	92	92	76	80	107	112	36+	39.0	33.0	33.9	34.2	35.5		87.8				
1-10-49	62	100	109	78	57	77	92	36+	37.6	32.3	32.7	33.6	34.8		87.0	88.1			
1-13-49	76	123	122	97	77	102	122	36+	41.7	32.3	33.4	33.7	34.8		87.9	87.1			
1-18-49	46	104	111	100	65	78	95	36+	39.1	33.1	33.8	35.0	35.2		87.0	80.6			
1-20-49	64	101	106	95	81	105	97	36+	40.5	33.9	35.0	35.1	35.8		85.7				
1-24-49	56	84	108	82	63	71	93	36+	37.9	33.1	31.9	34.6	35.4	33.9	85.9	87.9			

Note: Underlined values are averages for less than three samples.

Table 5 (Cont'd)

Date	Cone Index								Moisture Content						Density				
	0	3	6	12	18	24	30	Depth 150 C I	0-1	1-6	6-12	12-18	18-24	24-30	1-6	6-12	12-18	18-24	24-30
1-26-49	27	69	108	110	86	89	150	29	37.9	37.4	34.1	36.2	35.5		83.2	83.7			
2- 3-49	40	116	118	100	70	79	102	36+	36.3	33.8	36.3				82.6				
2- 7-49	54	102	120	117	84	93	150	27	42.1	33.9	33.6	34.0	35.5		83.2		82.6	83.0	
2-10-49	49	95	109	79	51	74	107	36+	40.1	34.4	35.2	34.8	36.0		83.1		80.6	83.1	
2-14-49	77	104	118	92	73	106	120	36+	36.3	32.5	33.7	33.2	33.8		84.3				
2-17-49	84	113	115	110	107	123	150	25	41.1	34.5	33.9	33.2	34.4		85.1		82.1	83.1	
2-21-49	46	103	111	110	86	99	119	35	50.7	37.0	34.0	41.2	38.1		84.7	86.1		84.0	
2-28-49	23	138	139	107	87	94	150	28	44.3	31.7	33.6	33.7	35.1		87.1	84.7	84.3	88.7	
3- 3-49	26	133	117	73	52	78	102	36+	39.0	33.1	33.1	33.3	35.4		86.6		82.2	85.3	
3- 7-49	83	148	122	85	59	83	115	36	37.1	30.1	34.4				87.0				
3-10 49	37	145	143	150				7	40.5	32.0	32.2	33.6	34.6		88.3				
3-15-49	82	140	135	118	150			16	39.6	31.7	34.0	34.2	36.0		89.8		84.6	82.9	
3-17-49	81	140	137	112	110	150		20	36.0	30.8	32.3	32.8			89.2			83.8	
3-21-49	117	142	137	127	150			15	32.7	29.3	33.0	31.7			89.2				
3-23-49	60	124	115	86	66	89	116	33	41.0	32.4	33.7	34.9	36.5				84.0	83.4	
3-28-49	56	117	118	86	65	90	106	36+	38.2	33.3	33.5	33.4	35.6	35.6					
4- 4-49	95	125	124	86	80	107	119	36+	38.7	32.3	36.3	36.0	36.0						
4- 8-49	150							0	27.9	29.9	34.0								
4-11-49	74	144	142	98	82	105	117	36	34.9	31.2	32.9	36.3	37.2		85.4	82.8	83.0	83.1	
4-15-49	150							0	21.7	26.1									
4-18-49	150							0	17.6	25.1	33.1				86.4				
4-25-49	137	150						1	21.6	25.1	35.8	33.2	37.0		89.0	80.8	84.4		
4-28-49	54	130	124	98	89	101	150	28	36.5	31.5	34.5	33.2	32.9	33.2	88.1				
5- 2-49	55	134	133	115	110	150		20	38.0	32.8	36.2	33.5	37.1		86.5				
5- 9-49	150							0	16.5	26.8	33.8				87.3				
5-16-49	150							0	10.3	18.4	24.7								

Note: Underlined values are averages for less than three samples.

Table 5 (Cont'd)

Date	Cone Index								Moisture Content						Density				
	0	3	6	12	18	24	30	Depth 150 C I	0-1	1-6	6-12	12-18	18-24	24-30	1-6	6-12	12-18	18-24	24-30
5-23-49	150							0	8.7	16.5									
5-31-49	97	150						2	31.9	27.8									
6- 6-49	150							0	14.3	22.7	28.6	27.4	26.0		89.5	79.6	80.5	81.6	
6-13-49	68	144	150					4	35.2	29.2									
6-20-49	150							0	20.8	24.7	30.4				93.8				
6-27-49	150							0	21.1	24.6	28.8				94.1				
7- 5-49	150							0	30.2	26.7	28.0				90.1				
7-11-49	150							0	13.8	19.7	24.8	24.0	23.5						
7-18-49	127	150						1	27.9	26.2	26.9	22.1	27.1		88.0	85.3	82.0	85.6	
7-25-49	81	144	150					4	33.7	30.2	30.2				88.9				
8- 1-49	58	150						2	29.7	28.6									
8- 8-49	150							0	23.8	24.7	29.6				88.9				

Note: Underlined values are averages for less than three samples.

Table 5 (Cont'd)

Date	Cone Index								Moisture Content						Density				
	0	3	6	12	18	24	30	Depth 150 C I	0-1	1-6	6-12	12-18	18-24	24-30	1-6	6-12	12-18	18-24	24-30
1-26-49	27	69	108	110	86	89	150	29	37.9	37.4	34.1	36.2	35.5		83.2	83.7			
2- 3-49	40	116	118	100	70	79	102	36+	36.3	33.8	36.3				82.6				
2- 7-49	54	102	120	117	84	93	150	27	42.1	33.9	33.6	34.0	35.5		83.2		82.6	83.0	
2-10-49	49	95	109	79	51	74	107	36+	40.1	34.4	35.2	34.8	36.0		83.1		80.6	83.1	
2-14-49	77	104	118	92	73	106	120	36+	36.3	32.5	33.7	33.2	33.8		84.3				
2-17-49	84	113	115	110	107	123	150	25	41.1	34.5	33.9	33.2	34.4		85.1		82.1	83.1	
2-21-49	46	103	111	110	86	99	119	35	50.7	37.0	34.0	41.2	38.1		84.7	86.1		84.0	
2-28-49	23	138	139	107	87	94	150	28	44.3	31.7	33.6	33.7	35.1		87.1	84.7	84.3	88.7	
3- 3-49	26	133	117	73	52	78	102	36+	39.0	33.1	33.1	33.3	35.4		86.6		82.2	85.3	
3- 7-49	83	148	122	85	59	83	115	36	37.1	30.1	34.4				87.0				
3-10 49	37	145	143	150				7	40.5	32.0	32.2	33.6	34.6		88.3				
3-15-49	82	140	135	118	150			16	39.6	31.7	34.0	34.2	36.0		89.8		84.6	82.9	
3-17-49	81	140	137	112	110	150		20	36.0	30.8	32.3	32.8			89.2			83.8	
3-21-49	117	142	137	127	150			15	32.7	29.3	33.0	31.7			89.2				
3-23-49	60	124	115	86	66	89	116	33	41.0	32.4	33.7	34.9	36.5				84.0	83.4	
3-28-49	56	117	118	86	65	90	106	36+	38.2	33.3	33.5	33.4	35.6	35.6					
4- 4-49	95	125	124	86	80	107	119	36+	38.7	32.3	36.3	36.0	36.0						
4- 8-49	150							0	27.9	29.9	34.0								
4-11-49	74	144	142	98	82	105	117	36	34.9	31.2	32.9	36.3	37.2		85.4	82.8	83.0	83.1	
4-15-49	150							0	21.7	26.1									
4-18-49	150							0	17.6	25.1	33.1				86.4				
4-25-49	137	150						1	21.6	25.1	35.8	33.2	37.0		89.0	80.8	84.4		
4-28-49	54	130	124	98	89	101	150	28	36.5	31.5	34.5	33.2	32.9	33.2	88.1				
5- 2-49	55	134	133	115	110	150		20	38.0	32.8	36.2	33.5	37.1		86.5				
5- 9-49	150							0	16.5	26.8	33.8				87.3				
5-16-49	150							0	10.3	18.4	24.7								

Note: Underlined values are averages for less than three samples.

Table 5 (Cont'd)

Date	Cone Index								Moisture Content						Density				
	0	3	6	12	18	24	30	Depth 150 C I	0-1	1-6	6-12	12-18	18-24	24-30	1-6	6-12	12-18	18-24	24-30
5-23-49	150							0	8.7	16.5									
5-31-49	97	150						2	31.9	27.8									
6- 6-49	150							0	14.3	22.7	28.6	27.4	26.0		89.5	79.6	80.5	81.6	
6-13-49	68	144	150					4	35.2	29.2									
6-20-49	150							0	20.8	24.7	30.4				93.8				
6-27-49	150							0	21.1	24.6	28.8				94.1				
7- 5-49	150							0	30.2	26.7	28.0				90.1				
7-11-49	150							0	13.8	19.7	24.8	24.0	23.5						
7-18-49	127	150						1	27.9	26.2	26.9	22.1	27.1		88.0	85.3	82.0	85.6	
7-25-49	81	144	150					4	33.7	30.2	30.2				88.9				
8- 1-49	58	150						2	29.7	28.6									
8- 8-49	150							0	23.8	24.7	29.6				88.9				

Note: Underlined values are averages for less than three samples.

PLATES

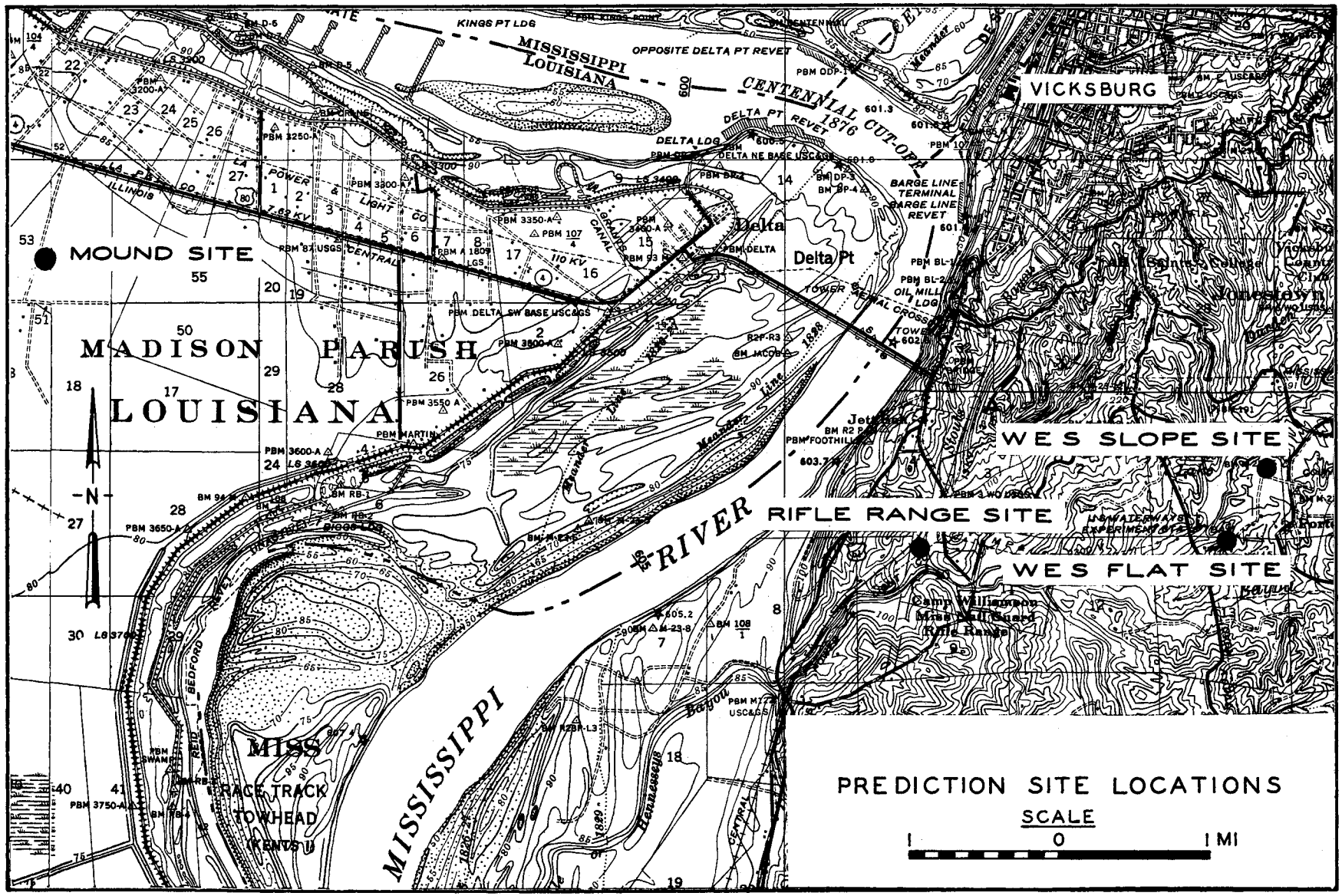
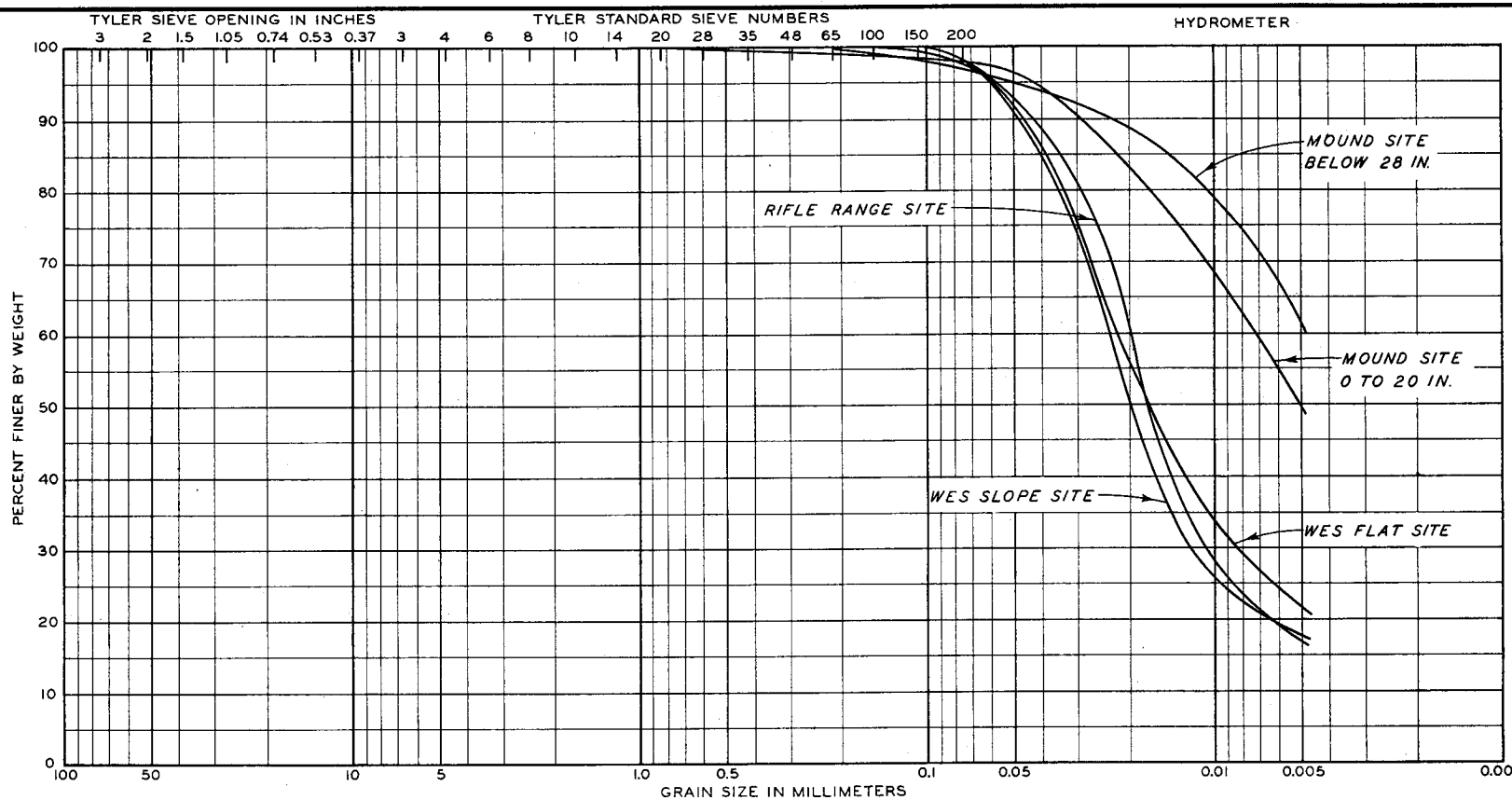

MOUND SITE
MADISON PARISH
LOUISIANA
MISSISSIPPI
MISSISSIPPI RIVER
VICKSBURG
WES SLOPE SITE
RIFLE RANGE SITE
WES FLAT SITE
Delta
Delta Pt
KINGS PT LDG
OPPOSITE DELTA PT REVET
CENTENNIAL CUT-OFF 1876
DELTA PT REVET
DELTA LDG
BARGE LINE TERMINAL
BARGE LINE REVET
TOWER CANAL CROSS
OIL MILL LDG
JETTY
FOOTHILL
POWER & LIGHT CO
LA P&L CO
ILLINOIS CENTRAL
RACE TRACK TOWHEAD (KENTS I)
Camp Williamson Miss. Nat'l Guard Rifle Range
Yazoo Diversion Canal
N
PREDICTION SITE LOCATIONS
SCALE
0
1 MI

PLATE 1



MATERIAL	LIQUID LIMIT	PLASTICITY INDEX	SPECIFIC GRAVITY
WES FLAT SITE LEAN CLAY	41	18	2.67
WES SLOPE SITE SILT	34	9	2.67
RIFLE RANGE SITE SILT	37	11	2.66
MOUND SITE FAT CLAY:			
0 TO 20 INCHES	56	26	2.73
BELOW 28 INCHES	84	52	2.74

SOIL CLASSIFICATION DATA
TEST SITES

PLATE 2

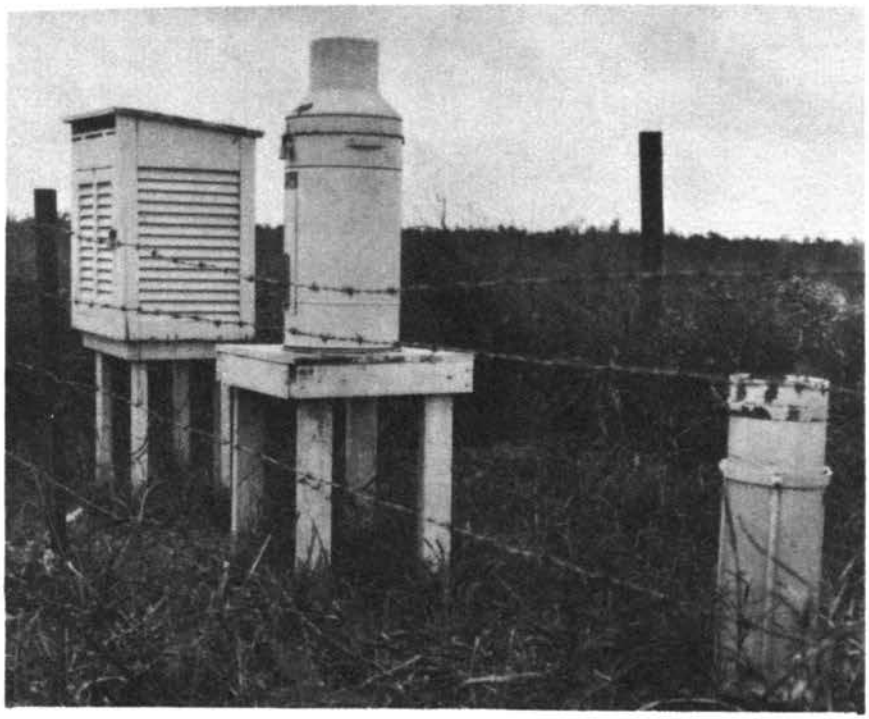


FIGURE 1

METEOROLOGICAL EQUIPMENT

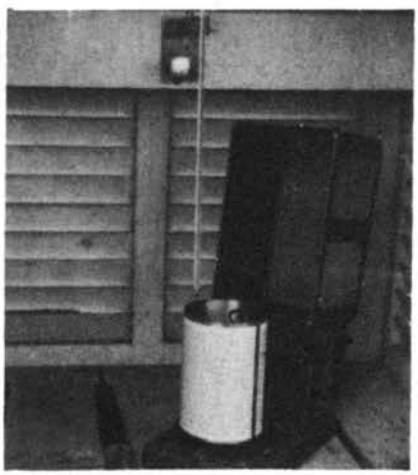


FIGURE 2

THERMOGRAPH AND THERMOMETER

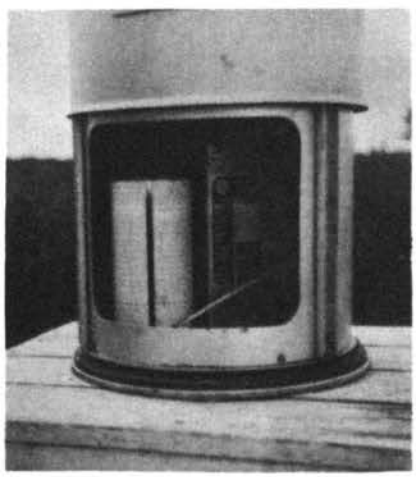
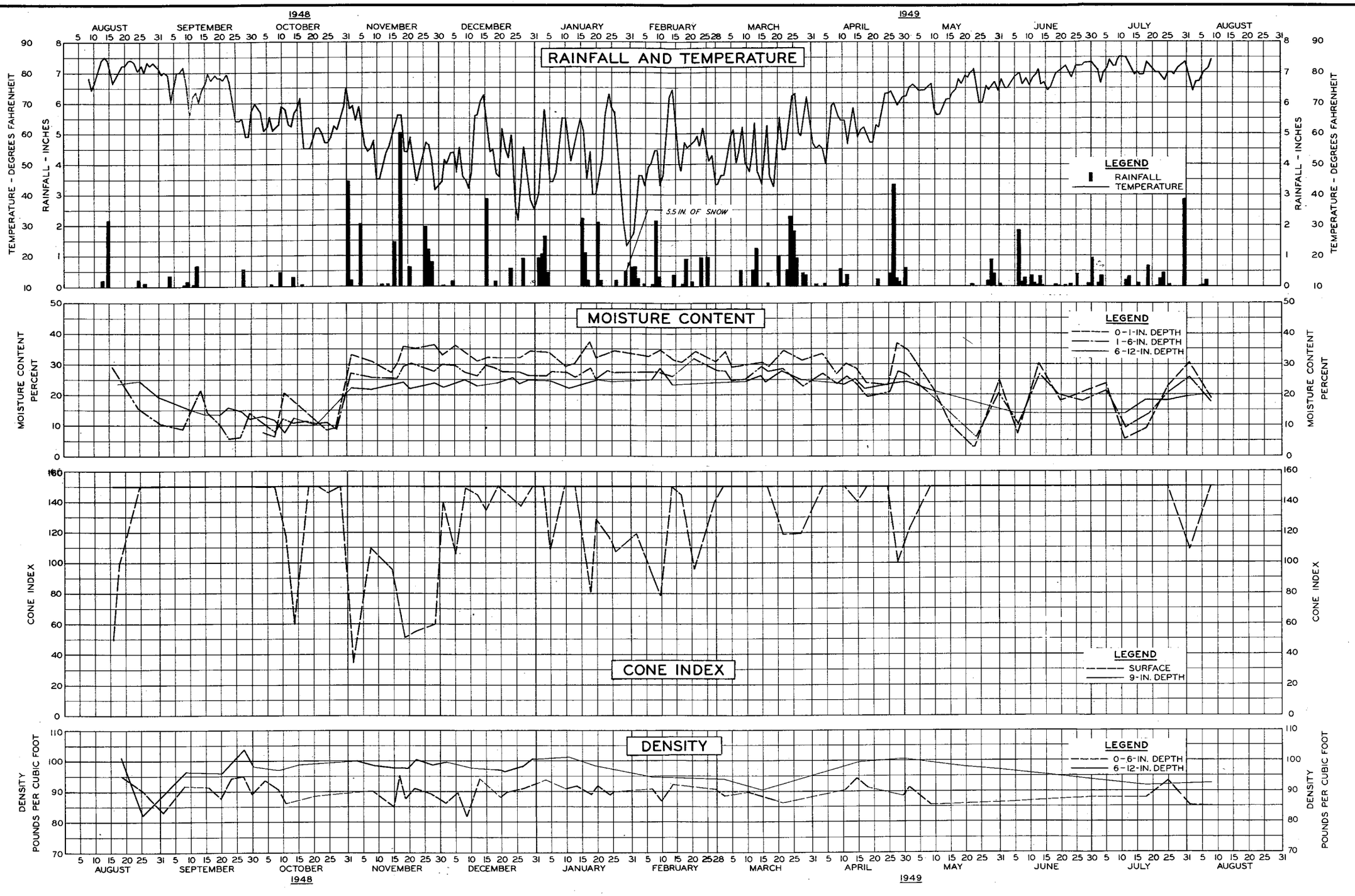


FIGURE 3

RECORDING RAIN GAGE

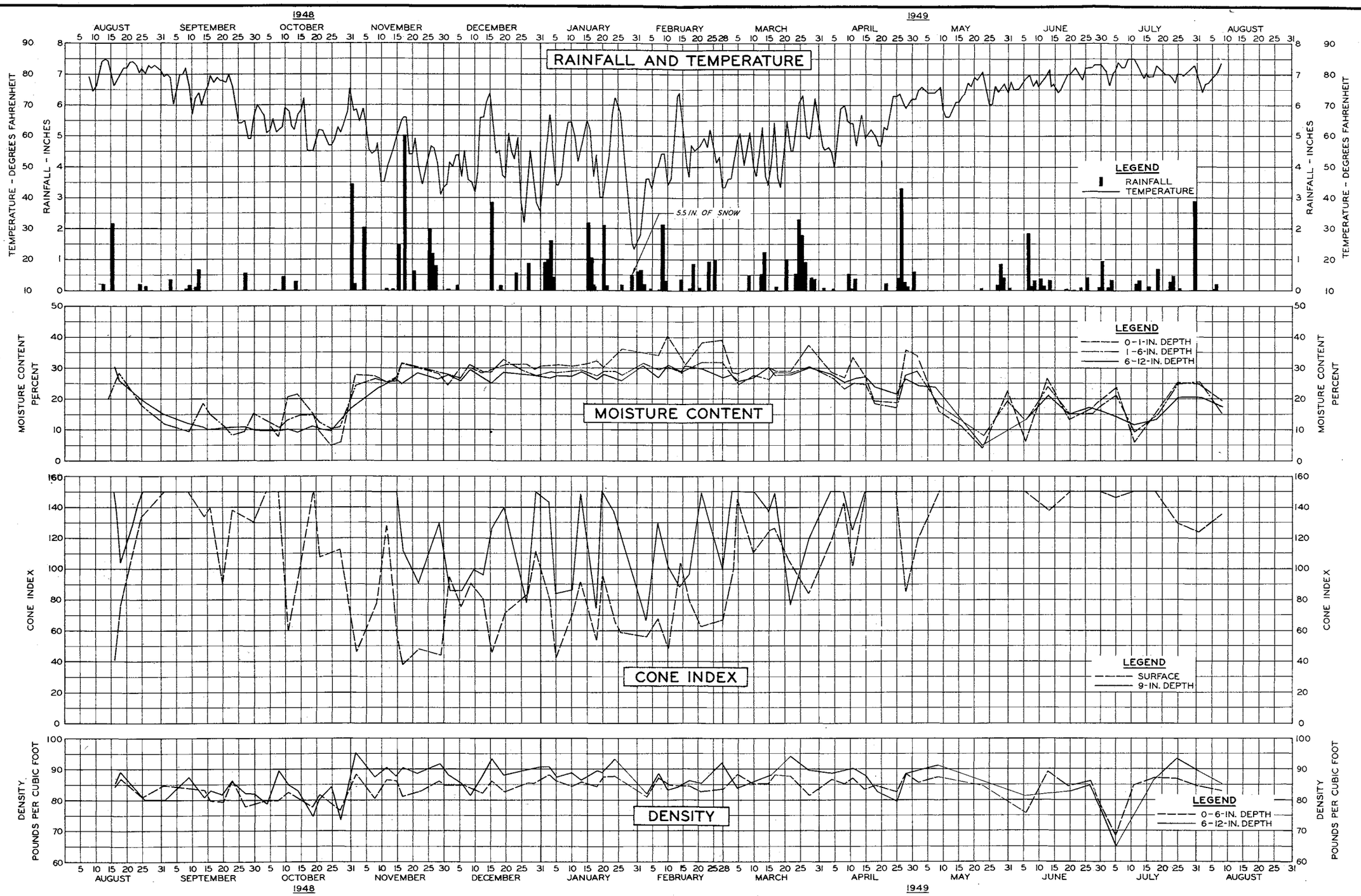
TYPICAL METEOROLOGICAL INSTALLATION



METEOROLOGICAL AND SOIL DATA FOR A ONE-YEAR PERIOD

W.E.S. FLAT SITE

PLATE 4



METEOROLOGICAL AND SOIL DATA FOR A ONE-YEAR PERIOD

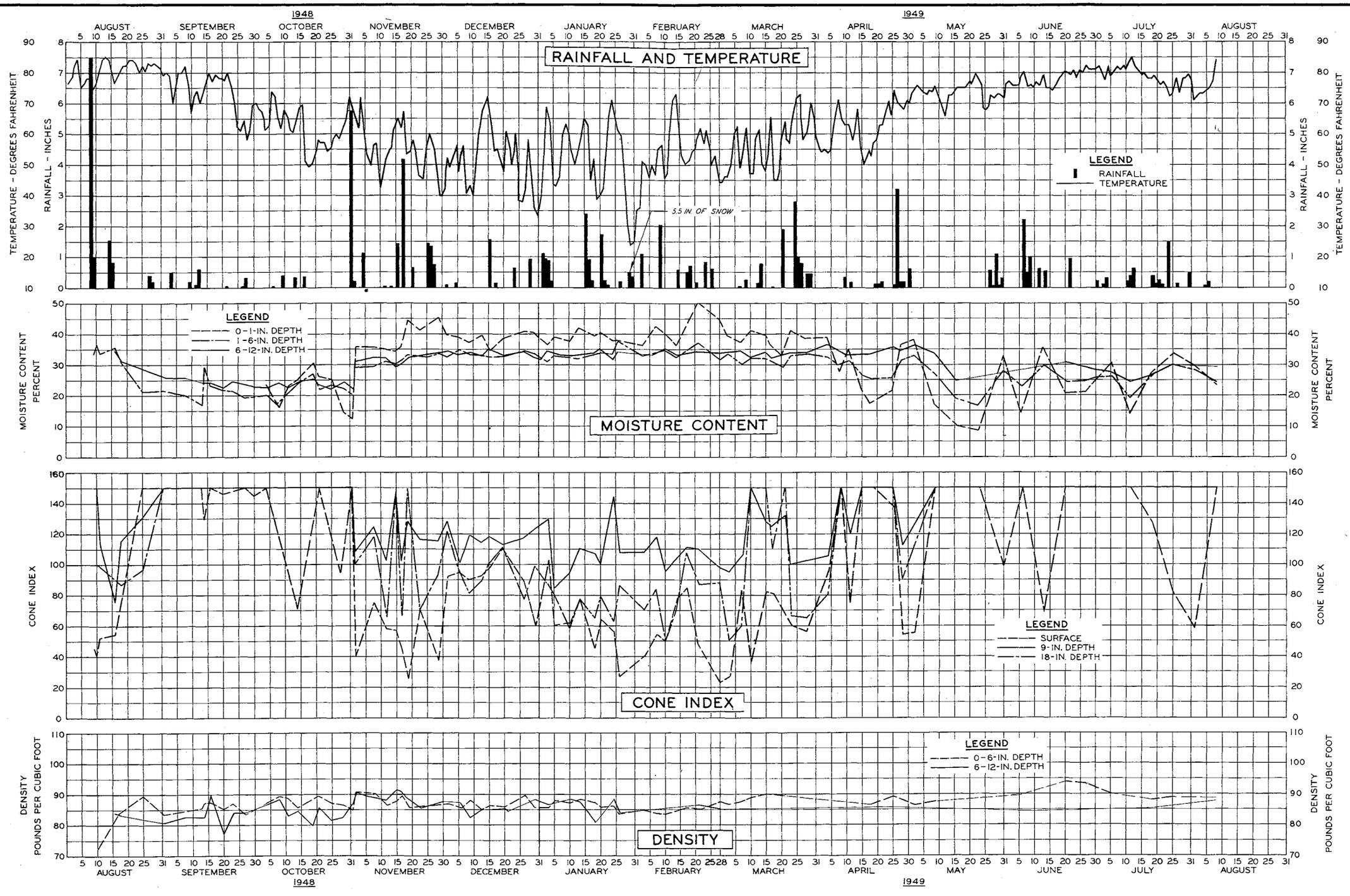
W.E.S. SLOPE SITE

PLATE 5

METEOROLOGICAL AND SOIL DATA FOR A ONE-YEAR PERIOD

RIFLE RANGE SITE

PLATE 6



METEOROLOGICAL AND SOIL DATA FOR A ONE-YEAR PERIOD

MOUND SITE

PLATE 7

W. E. S. SLOPE SITE

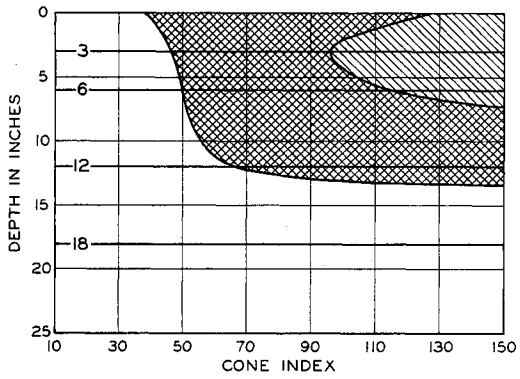


FIGURE 1

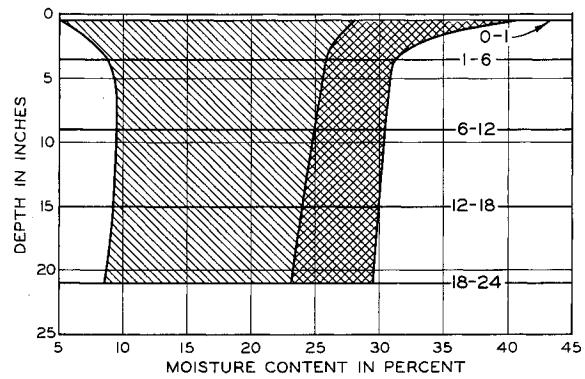


FIGURE 2

W. E. S. FLAT SITE

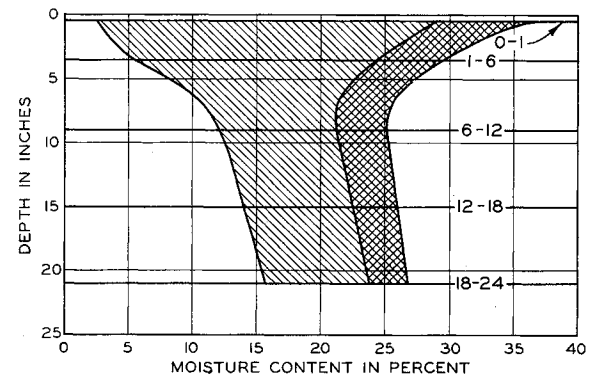


FIGURE 3

MOUND SITE

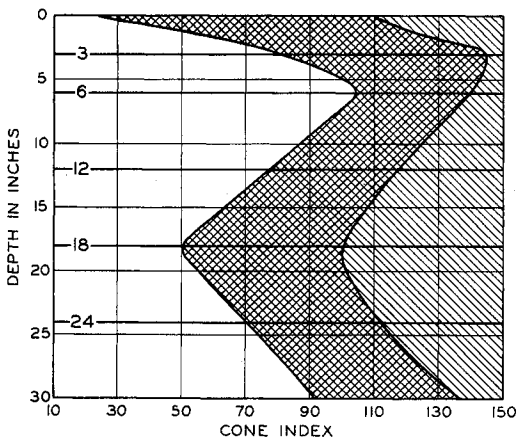


FIGURE 4

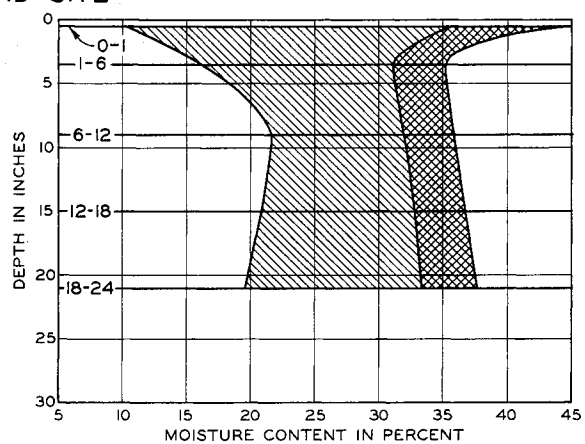
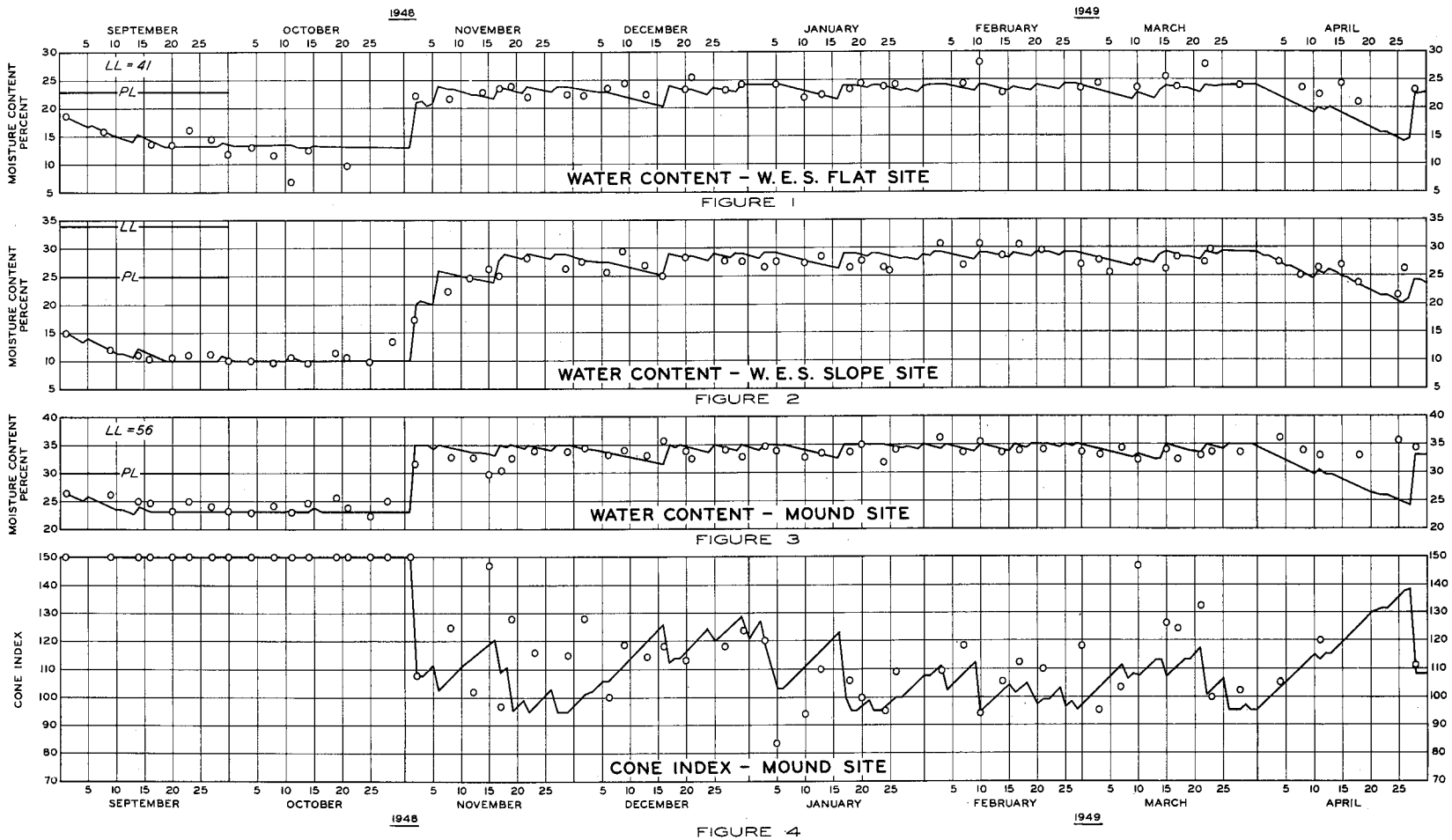


FIGURE 5

MOISTURE CONTENT AND CONE INDEX PROFILES

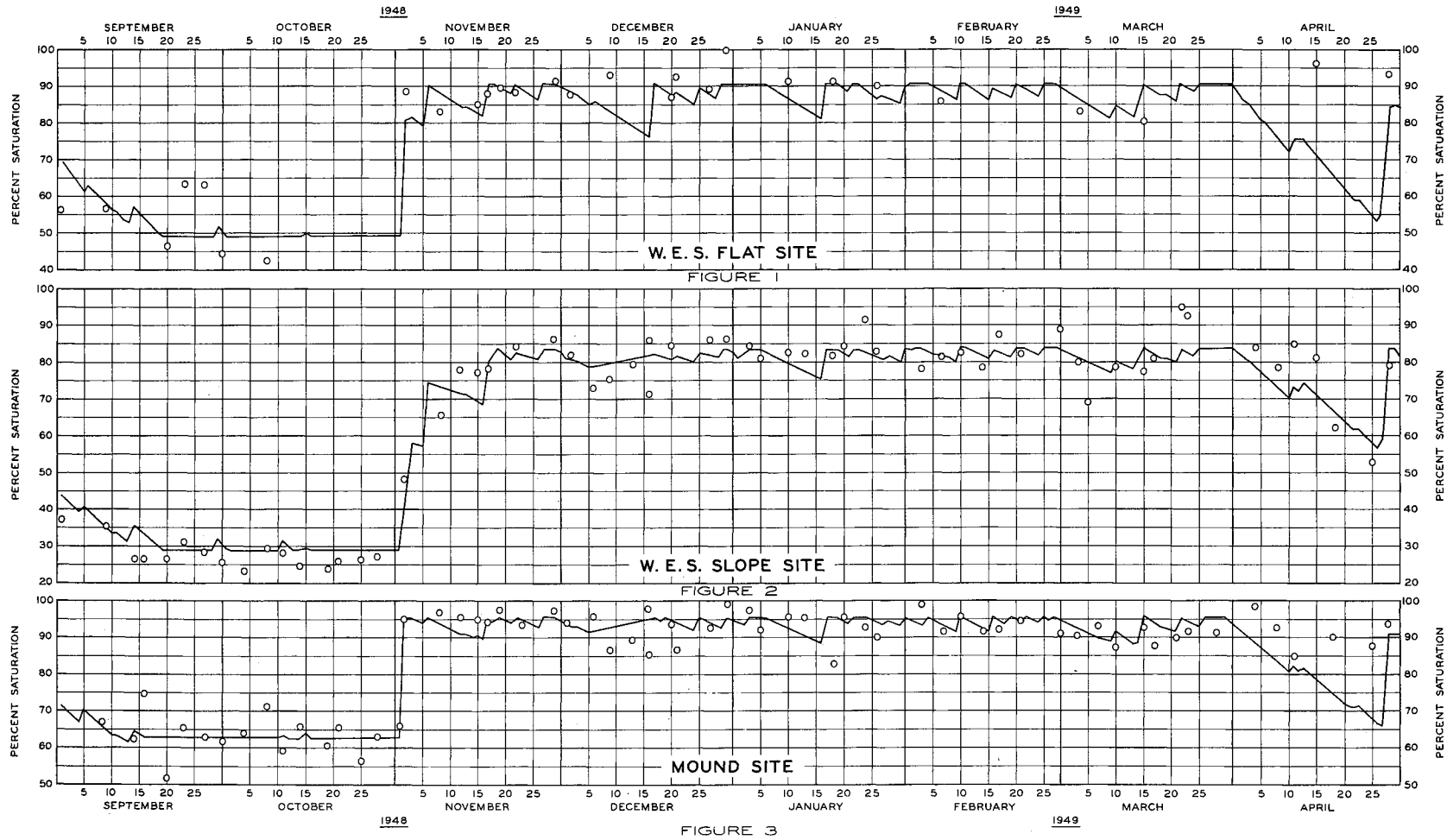
W. E. S. SLOPE SITE, W. E. S. FLAT SITE AND MOUND SITE

PLATE 8



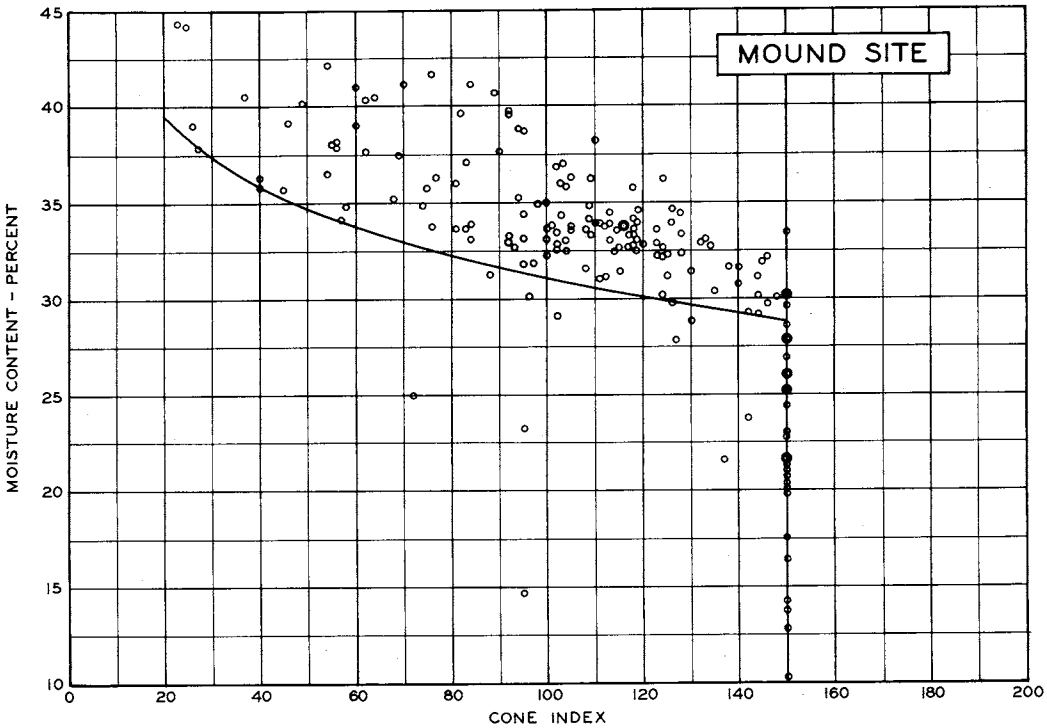
COMPARISON OF COMPUTED AND ACTUAL MOISTURE CONTENTS AND CONE INDEXES

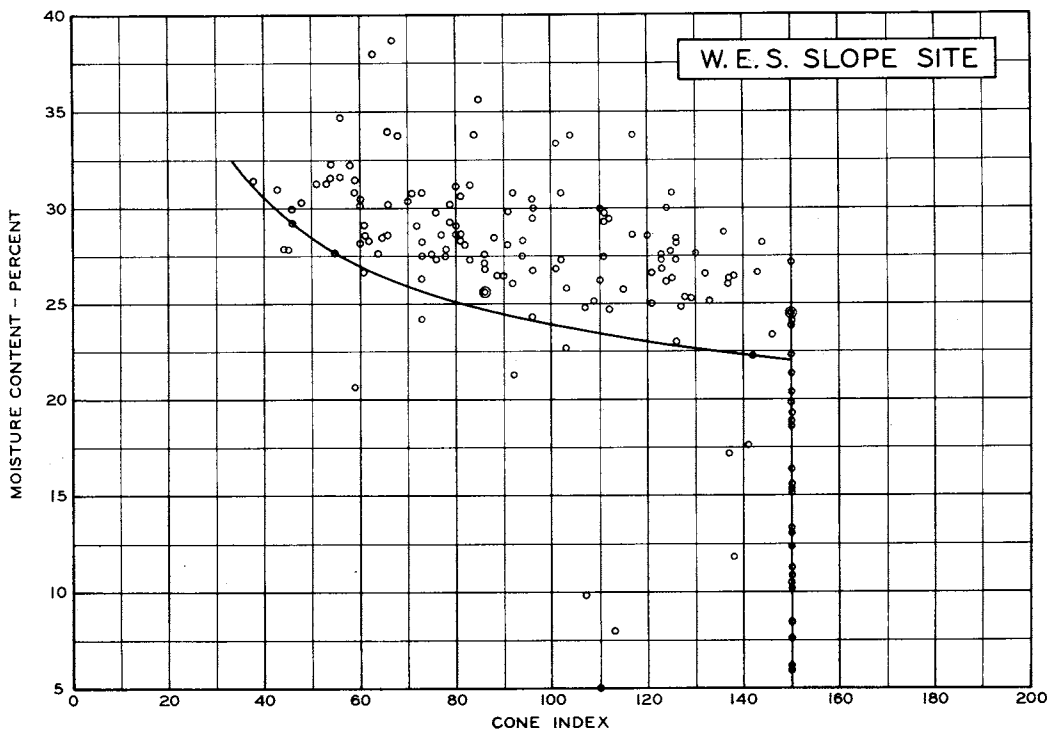
PLATE 9



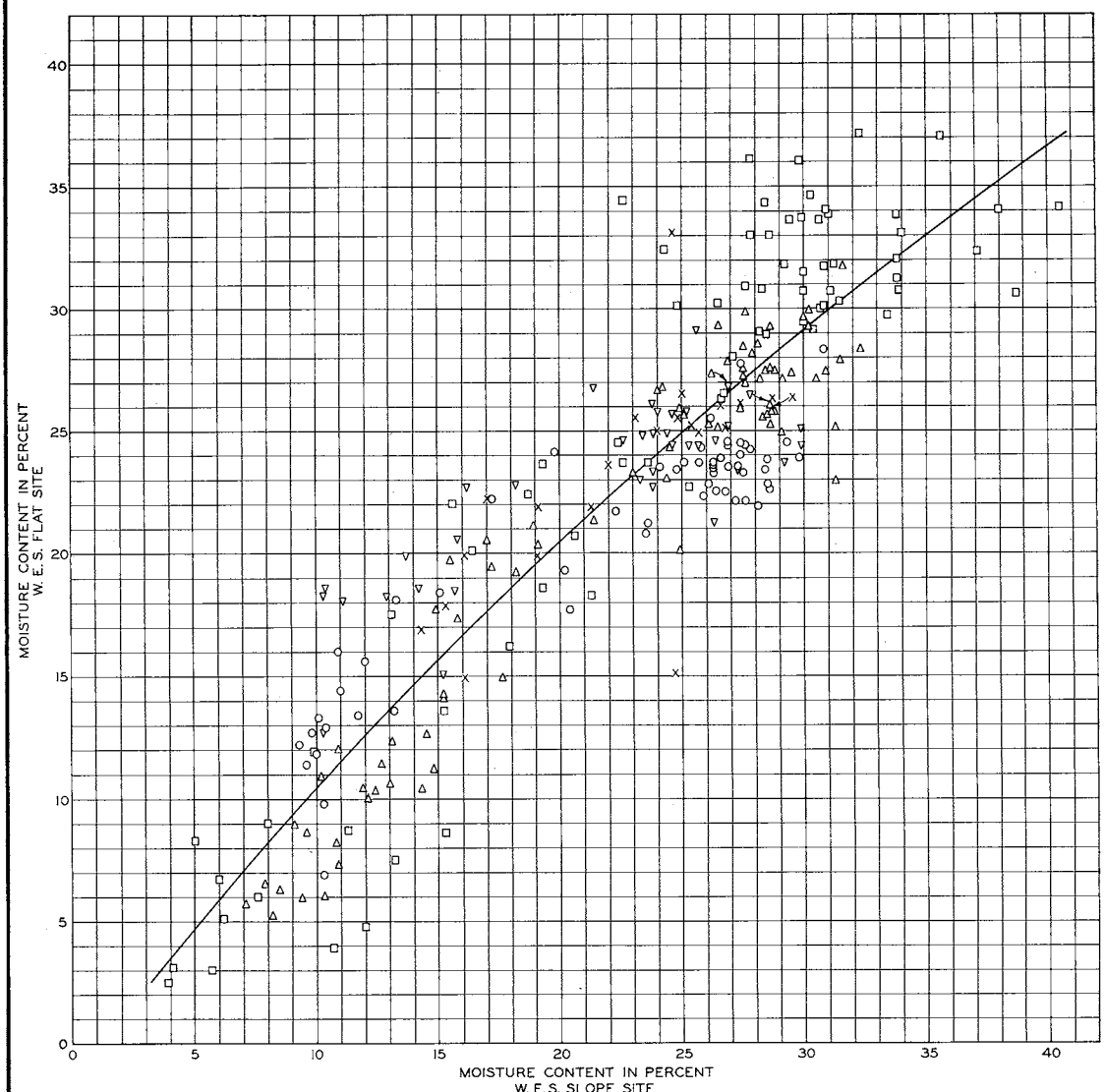
COMPARISON OF COMPUTED AND ACTUAL DEGREE OF SATURATION

PLATE 10





CONE INDEX - MOISTURE CONTENT
RELATIONSHIP FOR TOP 12 INCHES



LEGEND

- □ SURFACE – 0 TO 1 IN. IN DEPTH
- △ 1 TO 6 IN. IN DEPTH
- ○ 6 TO 12 IN. IN DEPTH
- ▽ 12 TO 18 IN. IN DEPTH
- X 18 TO 24 IN. IN DEPTH

SOIL MOISTURE AT W. E. S. SITES

PLATE 12